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Growing Up in Tell el-Amarna: An Examination of Growth and Non-specific Stress Indicators in New Kingdom Children.

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Growing Up in Tell el-Amarna:
An Examination of Growth and Non-specific Stress Indicators in New Kingdom Children

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by

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Abstract

The health status of the subadult skeletal remains from the South Tombs Cemetery at Tell el-Amarna were assessed by examining fluctuations in childhood growth and rates of skeletal indicators of physiological stress within a biocultural framework. The long bone standardization method outlined by Goode et al. (1993) was used to compare the South Tombs cemetery's cross-sectional growth data to subadult samples from other cemeteries during which major social, political, and economic changes were taking place. The comparative subadult samples included the HK43 cemetery from Hierakonpolis (Egypt), the African American Cemetery from Cedar Grove (Arkansas), and the St. Martin's Churchyard from Birmingham (United Kingdom). Incidences of skeletal stress markers (cribra orbitalia, linear enamel hypoplasias, and porotic hyperostosis) and diseases of malnutrition (scurvy and rickets) were examined to obtain a more holistic representation of the general health of the comparative populations. Result showed that the subadults from the South Tombs Cemetery were under tremendous childhood stress as evidenced by the reduced growth status and high rates of childhood stress indicators. Comparison of the biocultural models indicate that migration, population growth, and manufacturing were parallel factors contributing to the poor health and delayed growth seen in the South Tombs Cemetery and St. Martin's Churchyard samples.

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Dedication

I would like to dedicate this dissertation to my friends and family who have provided me with the support and encouragement needed to complete my dream.

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Chapter I

Introduction

The research in this dissertation focuses on identifying the biosocial factors that impacted the health, growth, and development of the children from the South Tombs Cemetery at Tell el-Amarna, Egypt. Tell el-Amarna is the modern location of the Pharaoh Akhenaten's capital city, Akhetaten. No city or temples existed at Tell el-Amarna prior to the construction of Pharaoh Akhenaten's capital (c. 1346 BCE) and the city was abandoned shortly after the Pharaoh's death (c. 1331 BCE). Tell el-Amarna is an important site for studying Ancient Egyptian culture because it represents a sudden and brief snapshot of human habitation. This rare case represents an invaluable period in Egyptian history during which major political, economic, and social shifts took place. Due to the short inhabitation of the city (approximately 17 years) the adult skeletal remains of the South Tombs Cemetery can tell us little about what it was like to grow-up in the capital city during the reign of Akhenaten; however, the remains of the children can give us a glimpse. There are 172 subadult skeletons that have been excavated from the South Tombs Cemetery, comprising approximately 40% of the skeletal population. Through the study of children, a wealth of information can be obtained on the social and physical lives of people in the past, such as growth and development, diet, age at death, trauma and disease (Lewis 2007).

Despite the large number of subadult remains found in mortuary contexts, children are often overlooked and remain understudied in archaeology due to excavator and researcher unfamiliarity with subadult remains (Baker et al. 2005). Skeletal remains of children are often misidentified as animal bones when recovered (Lewis 2007). In addition, children were believed to be invisible in the skeletal record and were seen as non-participants, or inactive members of society and considered insignificant to archaeological agendas (Baxter 2005). With the publication of Lillehammer's article in 1989, *A Child is Born: A Child's World in an Archaeological Perspective*, a movement began for critical biosocial investigation into children and childhood in the past. A social framework, borrowed from many of the other social fields, started to be built and applied to the archaeological interpretation of children (Schwartzman 2005).

By studying children and childhood, archaeologists can get a better understanding of how learning and acculturation occur within a society. Childhood is a time of learning. Games and play serve the social function of teaching and preparing children for adulthood. It also serves as a way to pass down ideas, beliefs, customs, and social/ritual behavior (Lillehammer 1989). Play is not mimicry, but seen more as a tool in which children are able to better understand their culture and world (Schwartzman 2005; Thomas 2005). Childhood is also a place where social change can often take place. Ideas are being interpreted and changed through the developing child. The quality of life for children is highly dependent on socioeconomic factors, as well as physical changes taking place in their environment. Economic based studies have shown that the type of economy being employed (family produced versus market based) changes how the child is viewed within the society as well as the length of childhood (Burgarin 2005; Lillehammer 1989:92). Social disparities have the ability to affect the quality, quantity, or timing of life history traits, such as the age of weaning, number of offspring, etc. Economic or political changes can affect the health of the child and result in physiological changes in the child that can be detected in the bioarchaeological analysis (Mays et al 2008; Mays et al. 2009).

The evaluation of juvenile growth and development has been used to reconstruct the health status of children and societies in the past. Johnston (1962), who examined linear growth among infants and children found at Indian Knoll, conducted the earliest archaeological studies of human growth and development from subadult skeletal remains. He compared subadults younger than five years of age from Indian Knoll to the participants used to create the Maresh standards in the 1950s to identify differences in growth velocity. This study would spark future endeavors to examine growth in archaeological populations (i.e. Alfonso-Durruty 2011; Armalegos et al. 1972; Batey 2005; Goode et al. 1993; Good-Null 2002; Hoppa 1992; Hoppa and Gruspier 1996; Hummert and Van Geryen 1983; Jantz and Owsley 1984; Kaczmarek 2012; Lewis 2007; Mays 1995; Mays et al 2008; Mays et al. 2009; Miles and Bulman 1995; Saunders et al. 1993; Sciulli 1994; y'Edynak 1976).

There have been very few growth and development studies conducted on Ancient Egyptian subadult remains (i.e. Armalegos et al. 1972; Batey 2005; Kaczmarek 2003; Kaczmarek 2012; Wheeler 2009). Batey (2005) examined skeletal growth at the Predynastic workman's cemetery HK43 from Hierakonpolis, Egypt, and found that these Predynastic Egyptians had poor growth when compared to the modern Maresh standard. Armelagos et al. (1972) identified growth delays among prehistoric Nubians in the Sudan. Wheeler (2009) examined the growth and health status among Roman-Egyptian children from Kellis 2 cemetery, Dakhleh Oasis, Egypt. Kaczmarek (2003, 2012) examined fluctuations in growth and rates of skeletal stress markers in subadult skeletons recovered from the Greco-Roman cemetery at Maina el Alamine and a Late Greco Period at Saqqara. She conclude that due to the high prevalence of skeletal stress markers and delayed subadult growth that the life of children was defined by poor health and nutrition.

More research need to be conducted on the growth and development of Ancient Egyptian children as it provides us with a unique research opportunity due to its rich archaeological materials and skeletal remains, as well as an iconographic and written record that can assist us with both identifying and contextualizing children and childhood. The hot/dry climate of Egypt has allowed for better skeletal preservation. Iconographic evidence and written records provides us with insight on how Ancient Egyptians regarded and treated children without having to rely on modern western preconceptions. Egypt's deep history allows us to identify changes in the cultural views and treatment of children over time. It also allows us to examine how these fluctuations affected the general health and wellbeing of the juveniles through the examination of the subadult skeletal remains.

The South Tombs Cemetery represents a unique chance to expand our understanding of children in the past and to examine how major economic, political, and religious changes affect the wellbeing of children. By combining the rich ethnographical and the historical documentation of Ancient Egypt with a bioarchaeological analysis of indicators of physiological stress and an examination of changes in childhood growth, I will provide a more developed and holistic perception of what it was like to grow up and live during the reign of the Pharaoh Akhenaten. Historical context of the reign of Akhenaten is outlined in Chapter II to provide an understanding of the social evolution that took place during the rule of Akhenaten. Chapter III will elaborate further on the theoretical and methodological approaches and concerns of examining children in the bioarcheological record, such as aging and sexing. Chapter IV will provide a review of the biocultural and theoretical frameworks that are used in this investigation. The archaeological and bioarchaeological investigations that have taken place at the South Tombs Cemetery is summarized in Chapter V. That chapter also includes the archaeological context and discussion of the comparative samples, which include the HK43 cemetery from Hierakonpolis (Egypt), the African American Cemetery from Cedar Grove (Arkansas), and the

St. Martin's Churchyard from Birmingham (United Kingdom). Chapter VI presents the long bone standardization method outlined by Goode et al. (1993) that was used to compare the South Tombs Cemetery's cross-sectional growth data to subadult samples from other cemeteries. Chapter VII examines and evaluates the skeletal stress indicators that have been recorded for each skeletal population. Chapter VIII presents the results of the analysis and provides an assessment of the results within their unique historical and social contexts. Conclusions and future endeavors are discussed in Chapter IX.

Chapter II

Historical Context of Tell el-Amarna

The Pharaoh Akhenaten came to power in circa 1348 BCE (Kemp 2012). During his reign, he and his chief wife, Nefertiti, would be responsible for a major religious revolution that would result in significant cultural, iconographic, linguistic, and economic changes throughout the Egyptian Empire (Van De Mieroop 2011). The god Amun would be castoff and replaced in eminence by the Aten, a deity represented by the sun's disc. He would move the religious capital out of Thebes in search of an untarnished land where no previous god or goddess had been worshipped. His capital city, Akhetaten, would rise from the desert sands in a few short years. His vision would be short-lived (17 years) and abandoned shortly after his death in circa 1331 BC (Shaw 2000). His successors would attempt to cleanse Egypt of Akhetaten's influence and memory by removing his name and image from inscriptions, omitting him from later king lists, and dismantling his temples (Kemp 2012). This raises important questions for Egyptologists, archaeologists, and biological anthropologists. How was Akhenaten able to coordinate and implant his religious revolution? What was the reason for the eventual desertion of his new capital and religious beliefs? Was life in Akhetaten not as prosperous as the texts and illustrations might suggest? The purpose of this chapter is to review the current historical literature published about the rise and fall of the Pharaoh Akhenaten and his city, Akhetaten.

Amenhotep III's Successor

Akhenaten was the son of the previous Pharaoh Amenhotep III and his wife, Tiye (Van de Mieroop 2011). Akhenaten's father had ruled Egypt for 38 years as he had come into power as a young boy. Egypt had prospered during the reign of Amenhotep III. The country had become more powerful and wealthier than any previous time period in Egyptian history (Shaw 2000). His reign was a period of peace thanks to the treaty with Mitanni, and a movement towards international diplomacy had begun for Egypt (Shaw 2000). No longer was Egypt a divided nation, but had become a strong independent state whose power had expanded past its borders (Murane 1995). Within the country, Amenhotep III's large-scale monumental building endeavors took place throughout the Egyptian empire demonstrating the lavish wealth that had been amassed by the Egyptian rulers (Van de Mieroop 2011). The focus of building projects during his reign was on the building of temples for the worship of the gods rather than on war conquests, which provides evidence that this was a time of mainly prosperity and peace in Egypt (Redford 2013).

Amenhotep III used Thebes as his religious capital for the country, while Memphis was the administrative center for Egypt's government, as it had been for many kings that had come before him (Shaw 2000). Thebes' local god, Amun, had risen in status within the Egypt pantheon of gods during the 18th dynasty (Murnane 1995: 4). He had been united with the sun god, Ra, and was being worshipped throughout all of Egypt as Amun-Ra, the king of the gods. The pharaoh "was the bodily son of Amun born from the union of the god with the queen mother in a sacred marriage that was ritually reenacted during the annual Opet Festival in Amun's temple at Luxor" (Shaw 2000: 273). According to Murnane, the Opet Festival "thus affirmed the interconnection between the dynasty's mortal kings and the divine essence that took possession of them, neatly serving the joint purposes of political and divine legitimation" (1995: 2). The spiritual association between the god Amun and the pharaoh demonstrates the prominent station the god had achieved in the New Kingdom religion prior to Akhenaten coming into power. This meant the priesthood of Amun had come to rival the pharaoh in wealth and power (Reeves 2001).

There is much debate among scholars over when Akhenaten's rule actually started, or whether he was intended to succeed his father as pharaoh (Kemp 2012; Shaw 2000; Van de Mieroop 2011). Early in Amenhotep III's rule another heir and son, Thutmose, had been identified in inscriptions as the eldest son, providing support that Akhenaten was not the first choice to inherit the throne (Shaw 2000). Kemp (2014) compares the omission of Akhenaten's name from subsequent ruler's list to that of Queen Hatshepsut, suggesting that perhaps his line of succession was not legitimate. However, Van de Mieroop (2011) intimates there was an easy transition from Amenhotep III to Akhenaten, and proposes a possible co-regency between Amenhotep III and Akhenaten that may have taken place during the end of his father's reign. Either way, Akhenaten did succeed his father, legitimately or not, and would be responsible for implementing major religious and political reforms during his reign.

Akhenaten's Religious Reforms

Akhenaten's official birth name (nomen) and the name he possessed when he became pharaoh was Amenhotep IV, which payed homage to the god Amun of Thebes (Van de Mieroop 2011). He officially changed his name during the fifth year of his reign and cut all ties with the god Amun. Akhenaten would attempt to remove Amun from prominence within the Egyptian pantheon by replacing him with the Aten. Akhenaten started his devotion to the Aten early in his reign by building monuments to the deity in Thebes, and would eventually build a new capital center devoted solely to the Aten (Kemp 2012).

The Aten was the physical representation of Ra-Harakhty as a solar disc (Van de Mieroop 2011). Early depictions of the Aten represent him in a more traditional Egyptian manner, as a falcon-headed man with a solar disc placed a top of his head (Shaw 2000; Van de Mieroop 2011). The traditional imagery of the god was abandoned and a new representation was implemented between the third and fifth year of Akhenaten's reign. The new representation was of "a disc with rays ending in hands that touch the king and his family, extending symbols of life and power towards them and receiving their offerings" (Shaw 2000:268). However, artistic modifications did not stop with the Aten's imagery but permeated all the art generated during Akhenaten's reign. Even Akhenaten's own depiction of himself diverged from traditional imagery shortly after his succession. He instructed his artists to depict their pharaoh with a "thin, drawn-out face with pointed chin and thick lips, an elongated neck, almost feminine breasts, a round protruding belly, wide hips, fat thighs, and thin, spindly leg" (Shaw 2000: 272). His wife, Nefertiti, and their daughters would also be depicted in this manner usually under the gift giving rays of the Aten. There was a fluidity and an intimacy in the imagery that was not seen previously in Egyptian art (Van de Mieroop 2011).

Akehenaten's main wife, Nefertiti, is portrayed as having a prominent role during his reign and achieving equal status as his consort, which was unheard of previously in Egypt's ruling families (Van de Mieroop 2011). Nothing is known of the familial lineage of Nefertiti. Her official title was the 'Great Royal Wife.' She is often portrayed in intimate scenes with her husband and her six daughters suggesting there was a close marital bond between the two royals. It is believed that she became an official co-regent to her spouse later in his reign taking the throne name Ankhetkheperura and her daughter Meritaten would have taken over her mother's duties as queen consort (Shaw 2000). Shaw (2000) contends that the need for a co-regent is possiblely proof that there was opposition and resistance to the socioeconomic changes implemented by Akhenaten. Any significant resistance from the people of Egypt would have resulted in the need for an individual who could reside outside of Akhetaten, but had the power to make decisions for the empire and to act on those resolutions.

Little is known about the role Nefertiti played in the religious reforms her husband implemented during her time. Van de Mieroop (2011) points out that due to her constant presence in illustrations and inscriptions that she must have played a prominent role in the religious changes her husband was executing. She also changed her name, like her husband. She incorporated Neferneferuaten, “the most perfect is Aten,” to the beginning of her name. In Karnak, a part of the Aten temple was exclusively dedicated to Nefertiti, which suggests that she was an active participant in the worship of the Aten.

Akhenaten began his reign by setting out on a monumental building project at Karnak by erecting a temple honoring the Aten, which was possibly located just east of Amun’s temple (Shaw 2000; Van de Mieroop 2011). Monetary support originally meant for the temples of Amun was being allocated for the creation of temples for the Aten (Murnane 1995; Shaw 2000; Van de Mieroop 2011). In previous generations, Amun’s high priest was chosen by the pharaoh and was considered to be the highest ranked priest of any deity, which made them overlords for all the priests in Egypt (Murnane 1995). The removal of monetary and exclusive sovereign support would have resulted in a demotion in status and reduced the political power for the Amun priests. A power shift would have ensued from Akhenaten’s religious changes and would likely have created resentment for those who were dependent on the prominent standing of the god Amun. This may have contributed to Akhenaten becoming discontented with the traditional capitals and their conventional gods, and led to the pharaoh's decision to create a new capital in which no previous deity had been worshipped (Kemp 2012; Shaw 2000).

Akhetaten

Akhenaten's persistent desire to distance himself from the previous spiritual and political elites resulted in a campaign to build a new capital city in a previously uninhabited location along the Nile between the original capitals of Thebes and Memphis (Kemp 2012; Van de Mieroop 2011). He selected the untainted stretch of desert as no previous god or goddess had been previously worshipped there. He called his city Akhetaten, "The Horizon of the Sun's Disc" (Kemp 2012). The city was home to approximately 20,000 to 50,000 people, and approximately 10,000 to 13,000 individuals are buried in cemeteries associated with Akhetaten (Stevens 2017). Despite most of the city being dismantled after the death of Akhenaten, Akhetaten is "the largest area of readily accessible domestic occupation from ancient Egypt" that can be visited according to Kemp (2012:17). The modern location of Akhetaten is Tell el-Amarna or more commonly referred to as Amarna.

Both the quick construction and dismantling of Akhetaten was made possible due to the new building technique of using smaller stone bricks, known as *talatat* blocks (Kemp 2012; Van de Mieroop 2011). According to Van de Mieroop (2011:201) the *talatat* blocks "measure 20.5 by 10 by 9.4 inches (52 by 26 by 24 centimeters) and weigh about 110 pounds (50 kilograms)." Builders were able to easily move and place the *talatat* blocks compared to the larger and more cumbersome stones previously used by the Egyptians for their monumental structures and temple building. The blocks could then be covered with plaster and decorated with scenes that were carved or painted on the surface. Due to their small size and maneuverability, *talatat* blocks could easily be recycled. Later Egyptians would disassemble the city and many of the monuments built by Akhenaten in an attempt to restore the traditional beliefs and customs. The blocks would be recycled and used in new construction projects for future pharaohs. Sometimes the carvings and inscriptions made during Akhenaten's reign were left on the blocks, or were only partially removed, and this has allowed archaeologists to identify blocks that had been removed from Akhetaten (Kemp 2012).

The city is believed to have encompassed a ten by eight mile (16 by 13 kilometers) stretch of land located along the Nile (Van de Mieroop 2011). The area west of the Nile was intended for agricultural use to support the growing population of the city. The locations of boundary stelae suggest that the original city was only supposed to encompass the area on the east bank (Kemp 2012). However, with the rapid expansion of the city, the agricultural west bank was later incorporated as an official part of Akhetaten. The urban core of the city located on the east bank consisted of administrative and religious buildings, as well as residential homes and artisan shops for the citizens of Akhetaten (Van de Mierooop 2011). This four-mile stretch of desert ran parallel to the Nile and was bounded by limestone cliffs to the east (Kemp 2012). This is where the tombs of the officials are located in both the north and the south areas of the range, and the royal tombs are located farther from town deep in the eastern mountains (Van de Mieroop 2011).

A wide royal road ran the length of the urban core connecting the northern and southern parts of the city (Van de Mieroop 2011). The northern part of the city contained the royal residents of the pharaoh and his court with the palaces situated along the riverbank. The center of the main city contained a cluster of ceremonial palaces, along with the Great and Small Aten Temples (Kemp 2012). This sacred center contained the "Window of Appearances," where the royal family would distribute gifts and offerings from the Aten to the state officials, a scene that is often depicted in many of the surviving imagery of the time (Van de Mieroop 2011: 205). The temples acted as places that the pharaoh could display his offerings to Aten on hundreds of stone tables (Kemp 2012). Depictions of the temple show offering tables piled high with food and drink that were often accompanied by incense and bouquets of flowers.

The building of the new capital and the continued construction projects throughout the inhabitation period of the city would have been a considerable endeavor, and would have required substantial capital and a massive labor force to execute (Kemp 2012). This would have led to the migration of thousands of people and their families to Akhetaten. This exodus of people across Egypt would have resulted in physical and psychological stresses on the immigrants who were required to leave their homes.

Many of the houses in the city belonged to tradesmen and craftsmen, as well as the residences for royal officials and advisors brought by the pharaoh (Van de Mieroop 2011). There is no distinction of wealth or status among the neighborhoods in the northern and southern suburbs (Kemp 2012). The size of the residences appears to indicate the status, or wealth of the individuals with larger estates being surrounded by smaller houses. Kemp (2012:163-166) posits that there was very little or no city planning in the construction of the Akhetaten. The city appears to have grown from the riverbank out into the desert and towards the eastern cliffs. Neighborhoods appear to be organized in a "patron-client relationship" in which the patrons in the largest estates would have claimed plots of land upon arrival, and their clients would then fill in the spaces between with their smaller residences creating small dependent villages (Kemp 2012:163). Kemp (2012:166) points out that despite there being no city planning, Akhetaten was in no way a "shantytown of the disadvantaged." It was a point of pride to reside next to those that were dependent on you and owed you deference as it demonstrated the wealth and status of the patron.

The Death of Akhenaten

The pharaoh Akhenaten died during the 17th year of his reign (Kemp 2012). The inhabitation of Akhetaten would also be short lived, as it was abandoned soon after the death of the pharaoh (Shaw 2000). The city itself was only inhabited 16 to 17 years at most before the capital was abandoned by royal decree during the reign of Tutankhamun (Kemp 2012; Shaw 2000; Van de Mieroop 2011). Although much of the city was later dismantled and the talatat blocks reused for future royal building endeavors, much of the city, tombs, and stelae remain intact (Kemp 2012).

There is much speculation over the succession following the death of the pharaoh Akhenaten. He was first succeeded by Neferneferuaten, whom some believe was Nefertiti as she had previously used this moniker as her own (Harris 1973; Van de Mieroop 2011). Nefertiti disappears from the archaeological record during the 12th year of Akhenaten's reign, a time of turmoil and a military campaign in Nubia. Some scholars suggest this disappearance is due to her falling out of favor with the pharaoh, and being replaced in prominence by another lessor wife, Kiya in hopes of fathering a son (Hornung 1999). As previously mentioned, others suggest that due to this turmoil Nefertiti became a co-regent to assist with governing of the state (Van de Mieroop 2011). Other scholars have theorized that Neferneferuaten may have been Akhenaten's eldest daughter Meritaten, or even another daughter who had been given the nomen Neferneferuaten from birth (Allen 2009; Gabolde 1998). At the very least, Neferneferuaten was a female due to the use of the feminine Ankhetkheprura in her throne name, and was regent, or co-regent, for a maximum of three years (Ven de Mieroop 2011; Vandersleyen 1995).

Smenkhkara, who is believed by some to be the husband of Meritaten and son-in-law to Akhenaten, succeeded Neferneruaten as pharaoh. (Clayton 1994; Schneider 1994; Van de Mieroop 2011). Smenkhkara, however, also takes on the moniker Neferneferuaten and uses the masculine throne name Ankhkheperura possibly distinguishing him from the previous ruler. This has led some scholars to suggest that Smenkhkara is none other than Nefertiti, who could have used a masculine persona to legitimize her rule, like the previous female pharaoh Hatshepsut (Shaw 2000). Either way, Smenkhkara continued the tradition of using Akhetaten as the capital, and the Aten cult continued to hold royal favor during his very brief reign as pharaoh (Van de Mieroop 2011).

Smenkhkara's successor was the young pharaoh Tutankhamun (Shaw 2000). He was original named Tutunakhaten, and changed his name to Tutankhamun when he became the pharaoh of Egypt (Van de Mieroop 2011). Although there is no consensus on the identity of his mother, some scholars agree that he was likely the biological son of the pharaoh Akhenaten (Shaw 2000; Van de Mieroop 2011). He was very young when he came into power, perhaps no more than nine or ten years old (Shaw 2000). He was already married to his probable half-sister Ankhesenamun, who was originally named Ankhesenpaaten, and was the daughter of Nefertiti and Akhenaten (Van de Mieroop 2011).

Tutankhamun and Ankhesenpaaten would both abandoned Akhetaten, and restored Amun and other traditional gods to their place of power (Shaw 2000). Restoration stela at Karnak built during the reign of Tutankhamun officially declares the reestablishment of the traditional gods, and suggests that Akhenaten's reforms had left Egypt in an abysmal state (Shaw 2000; Van de

Mieroop 2011). Only the reestablishment of the old gods and the removal of Akhenaten's influence would restore Egypt to its place of prominence and well-being. Tutankhamun's reign would begin the dismantling and overturning of all of Akhenaten's religious and political reforms, but Horemheb, who succeeded Tutankhamun's heir Ay, would be responsible for starting the process of removing Akhenaten and his successors from historical memory and official records (Van de Mieroop 2011).

Conclusion

Akhenaten was responsible for major religious and political changes during his reign, as well as the mass movement of thousands of people from their homes. This chapter has presented a brief summary of the historical literature on the reforms that took place prior to, during, and after the short period of time that Akhetaten was constructed and colonized. However, the historical literature has not provided us with information on how these changes affected the well-being and health of the citizens of Akhetaten. The written texts and illustrations from Akhetaten during the reign of Akhenaten suggests a time of prosperity and good health, where as other documents originating after his rule contradict those accounts. A legal text from after the Amarna Period goes so far as to refer to this period as "the time of the enemy of Akhetaten" (Kemp 2012: 1). The systematic removal of Akhenaten from Egypt's memory and historical records suggest that this was not a time of prosperity for the non-elites. The primary question therefore is how did these major social, political, and economic changes affect the citizens of Akhetaten? To answer this question this dissertation will examine the skeletal remains of the children, who grew up at Akhetaten.

Chapter III

Children and Childhood in the Archaeological Record

Children make up a significant portion of a population's demographic profile, and there has recently been a flurry of publications on the investigation of children and childhood in the archaeological record by both bioarchaeologists and social archaeologist (i.e. Bagwell 2002; Baker et al. 2005; Baker 1997; Baxter 2005abc; Bradley and Kamp 2002; Bugarin 2005; Chamberlain 1997; Crown 2002; Finlay 1997; Halcrow and Tayles 2008; Hammond and Hammond 1981; Hays-Gilpin 2002; Kamp 2001, 2002, 2005; Kamp and Whittaker 2002; Keith 2005; Lewis 2007; Lillehammer 1989; Lille 1997; Moore 1997; Park 2005; Perry 2005; Piper 2002; Rega 1997, 2000; Rothschild 2002; Scheuer and Black 2004; Schwartzman 2005; Scott 1999; Smith 2005; Sobolik 2002; Soafer 1997; Thomas 2005; Thompson et al. 2014; Whittlesey 2002). Evidence of children in the archaeological record has been found directly through mortuary remains containing subadult skeletal elements, along with associated burial artifacts (Lewis 2007). Despite the large number of subadult remains found in mortuary contexts, their mortuary remains have, until recently, been overlooked and understudied due to people's unfamiliarity with the non-adult skeletal elements, as well as outdated opinions that children are invisible in the archaeological record and were considered to be inactive or non-participants in their societies (Baxter 2005c; Baker et al. 2005). The use of gender theory amongst social archaeologist in the 1980's promoted the investigation of marginalized groups within the archaeological record, which resulted in children being perceived as active agents with their own unique social identities, material cultures, and experiences of the past (Lewis 2007). This chapter will review the current social and osteological literature associated with identifying and defining children and childhood in the archaeological record. It will also examine the cross-cultural variability of childhood experiences, and the need to create age categories that are both biologically and socially relevant to the society under investigation. The goal of this chapter is to provide socially and biologically relevant age categories utilized in the growth and health analysis of the South Tombs Cemetery's subadult skeletal population.

Archaeology of Children and Childhood

Children are often associated with the feminine and were regularly not included in archaeological investigations (Baker 1997). They were considered insignificant to misogynistic research agendas and were assumed to be invisible in the archaeological record. Children were too "random" to be unearthed in the archaeological landscape, and therefore, could only be used as a tool to describe deviation from the norm in artifact distribution or site-formation processes (Baxter 2005b). Moore (1997:255) once stated that "dogs have been more studied than children in the archaeological record." It would not be until the late 1980's with the gender critique of the male-biased archaeology that the door would open for the investigation into the world of children (Lewis 1997). The investigation into children and childhoods was slow to start as many feministic archaeologists viewed this line of research as promoting the "woman as mother" role that had been ascribed by male-biased beliefs about the gender (Sofaer Derevenski 1997).

In 1989, Lillehammer published an article, *A Child Is Born: the Child's World in an Archaeological Perspective*, in which she demanded that there should be more research conducted on children in the archaeological record. Her article would be considered the beginning of research on children and childhood in the archaeological record, as prior to her publication little to no consideration was given to the study of children in the past. The few studies that did exist prior to Lillehammer's article consisted of a brief mention of children in experimental ethnoarchaeological studies or listed as a possible cause for errors in site-formation processes (Baxter 2005c). Following Lillehammer's seminal article, a social framework, borrowed from many of the other social fields, began being applied to the archaeological interpretation of children and childhood (Schwartzman 2005). Various theoretical approaches have been incorporated into the investigation of children and childhood, such as agency (Baxter 2005b; Kamp 2005), landscape (Baxter 2005b), historical perspective (Lillehammer 1989) and ethnoarchaeology (Burgarin 2005; Thomas 2005). According to Kamp, there are five basic principles that need to be remembered when studying children:

> (1) it is important to differentiate between childhood and its stages as a cultural construct and the realities of particular children's lives, (2) the lived experiences of children may well not mirror perfectly the cultural definitions of the ideal or 'normal' childhood, (3) like adults, children are neither completely autonomous agents nor totally controlled by others, (4) childhood tends to be a gendered construct and children's experiences are usually gendered as well, and (5) children are active social agents, constantly negotiating their situation with adults and peers and a potential force for social transformation (2005:115).

The concept of child or childhood is a social construct in that it has culturally ascribed meaning and behaviors based on the individual's position within the human life cycle and within their society. These cultural beliefs and definitions of what it means to be a child are evolving at the same time the body is physically maturing within a specific historical context (Robertson 1996). By studying children and childhood, archaeologists acquire a better understanding of how learning and acculturation occur within a society. Childhood is a time of learning. Games and play serve a social function of teaching and preparing children for adulthood. They also serves as a way to pass down ideas, beliefs, customs and social/ritual behavior (Lillehammer 1989). Play is not mimicry, but is seen more as a tool in which children are able to comprehend their culture and the world (Schwartzman 2005; Thomas 2005). Childhood is a place where social change can occur: the developing child is learning and interpreting while simultaneously expounding and altering the social customs and traditions of their societies.

Defining Age

Biological age categories have been criticized for not taking into account social and cultural affects on growth and development (Halcrow and Tayles 2008). Childhood is a social concept in addition to being a biological construct. Age and gender both play an important role in our interpretations, as well as in determining an individual's place within society. Whether or not an individual is considered an adult is highly dependent on how their society views them. Social archaeologists argue that bioarchaeologists have not looked beyond the skeleton to the individual and their larger role within society (Halcrow and Tayles 2008). They suggest the use of culturally specific life stages that reflect the society's perception and expectations of its members at certain periods within their life history. This section will investigate how culturally specific life stages differ from the biological life stages suggested by life history theory, as well as obtain an understanding of how different social life stages affect a child's quality of life.

Three types of age categories have been used in archaeological research of past populations, and they include physiological, chronological, and social age (Halcrow and Tayles 2008). Physiological, or biological age is the age category that is most often used in bioarchaeological studies. Diagnostic indicators of maturation and degeneration are used in order to estimate the skeletal age of the individual (Buikstra and Ubelaker 1994; Lewis 2007; Scheuer and Black 2004). Although physiological age and chronological age represent two separate age categories, the terms are often employed interchangeable by researchers.

Chronological age is a Western concept of age that refers to the amount of time that has passed since the birth of the individual. Most attempts at trying to associate certain developmental stages to a specific chronological age have had little success (Bouquet-Appel and Masset 1982; Hoppa 2002; Jackes 2000; Lampl and Johnston 1996; Wood et al. 1992). Currently, the best method to age subadults is dental development and eruption, as environmental factors have less of an impact on their developmental timing, which is mainly genetically determined (Cardoso 2007).

The timing of life history traits has also been used to create broader biological age categories in an attempt to decrease the error associated with smaller age ranges. However, the emphasis on the use of age groups has brought about its own issues. These issues include inconsistencies in the way age groups should be split up and the use of different terminology between researchers, both within the field of bioarchaeology and between other disciplines. This has been particularly true for subadult individuals, or those commonly referred to as 'children'. This makes it particularly difficult to conduct comparative studies between archaeological sites. The terms like child, juvenile, infant, sub-adult, non-adult, adolescent and infant have not only been used to refer to this time period as a whole but also have been used to refer to a specific stage and various associated age range (Halcrow and Tayles 2008). For example, juvenile has been used to refer to the entire period prior to adulthood (Halcrow and Tayles 2008). Juvenile has been used to refer to individuals in the age groups from seven to anywhere between the ages ten and fourteen, as well as individuals from 15 to 22 years of age (Ascadi and Nameskeri 1970; Bogin 1997; Knussman 1988; Lewis 2007; Scheuer and Black 2004).

These terms have been used interchangeably by one researcher while at the same time are uniquely differentiated from one another by a different researcher. Some researchers have tried to simplify matters by only referring to individuals as being adults or non-adults/sub-adult/juvenile (Halcrow and Tayles 2008). However, what is considered an adult versus a non-adult also has its own complications. In the United States, an individual who has reached 18 years of age is considered an adult but this is not necessarily true for another country or society. For example, in Egyptology there are some discrepancies on when an individual becomes an adult (Janssen and Janssen 2007). Some Egyptian researchers argue that an individual becomes an adult at the onset of puberty and is possibly associated with a circumcision ceremony for males, while others have suggested that perhaps adulthood begins when the individual marries. Some have argued puberty alone is an indicator of adulthood. The fact that females on average reach puberty two years prior to males, combined with the fact that there is no way to sex sub-adults, does not allow for a clear and concise separation between these two age stages (Cameron and Bogin 2012). Osteologists have defined adulthood biologically and skeletally through the closure of the spheno-occipital synchondrosis (Ascadi and Nemeskeri 1970; Ferembach et al 1980). However, as Scheuer and Black (2004) states that this can range from anywhere between 11 to 19 years and anatomical textbooks state that this can occur anywhere between 17 to 25 years of age, indicating that this is not the most reliable indicator of adulthood. The dichotomy between adult and non-adult is not useful in paleodemographic research, as it does not take into account the various significant developmental stages and life events that take place during these years. The same critique has been made for the use of arbitrary five or ten-year intervals that ignore social and biological events associated with aging (Bogin 1997).

Identifying Biological and Social Life Stages in Ancient Egypt

As previously stated, there are many different types of age grouping systems that are being implemented by archaeologist and other scientific disciplines in the study of children and childhood (Ascadi and Nemeskeri 1970; Baker et al. 2005; Bogin 1999; Buikstra and Ubelaker 1994; Halcrow and Tayles 2008; Knussman 1988; Lewis 2007; Martin and Saller 1957; Panter-Brick 1998; Roksandic and Armstrong 2011; Scheuer and Black 2004). This section will review the various schemas that have been used to split early life into biologically and socially meaningful periods with the goal of identifying commonalities among the different age groups systems. The age stages identified from the comparison of the current schemas will be implemented in the comparative growth and health analysis of the subadult skeletal remains selected for this dissertation. As the South Tombs Cemetery is the focus of the research, cultural references, as well as archaeological examples will be taken from an Egyptian historical and archaeological literature to provide social context for each subadult age group identified (Janssen and Janssen 2007; Meskell 2005).

Table 1 is a visual representation of the different age groups that have been recommended and are currently used in various scientific fields (Ascadi and Nemeskeri 1970; Baker et al. 2005; Bogin 1999; Buikstra and Ubelaker 1994; Halcrow and Tayles 2008; Knussman 1988; Lewis 2007; Martin and Saller 1957; Panter-Brick 1998; Roksandic and Armstrong 2011; Scheuer and Black 2004). This table was created by the author and builds upon the research conducted by Halcrow and Tayles (2008) who attempted to identify the different age groups currently being implemented in anthropological scientific research. Various types of age groups have been utilized in bioarchaeology, depending on the country or continent in which the researcher is employed. The fields of medical anthropology, evolutionary biology, behavioral psychology, dental science, and developmental studies have also all proposed different age group categories. Buikstra and Ubelaker (1994) and Baker et al. (2005) are the main methods that are utilized in American bioarchaeological research. Knussman (1988), Martin and Saller (1957), Ascadi and Nemeskeri (1970), and Lewis (2007) are schemes utilized by European bioarchaeologists, which includes both British and Continental researchers. Medical anthropology employs the age stages that were used by Panter-Brick (1998). The method utilized in growth and development studies is an evolutionary and life history approach to age groups relying on the timing of biological changes to the body (Bogin 1997). Scheuer and Black (2004) is based on a behavioral scheme, while Charlesworth (2010) represents those proposed by developmental psychology. Dental age is one of the most accurate ways of aging non-adult individuals (AlQahtani et al 2010; Cardoso 2007). Dental development and eruption sequences are a strong biological foundation for identifying age stages and to discuss consistencies between the previously proposed age group systems due to them being highly genetically determined. AlQahtani et al. (2010) is the dental development and eruption sequence used in this analysis as it depicts dental age categories from 30 weeks in utero to 23 years of age.

Table 1: Visual representation of subadult age grouping systems.

Chronological Years	Birth	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Knussman 1988	Infans I								Infans II							Juvenile/Adolescence						
	Infans Ia			Infans Ib																		
Martin & Saller 1957	Infans	Young child							Infans II								Youth					
Ascadi & Nemeskeri 1970	Infant I					Infant II										Juvenile						
Lewis 2007	Infant	Child														Adolescence						
Scheuer and Black (2004)	Infant				Childhood			Juvenility: Girls **					Adolescence: Onset of Puberty									
								Boys**						Termination of Growth								
Dental age -eruption - formation (AlQahtani et al. 2010)	Deciduous Teeth						First Active Stage				Second Active Stage						3^{rd} Molar					
	1^{st} molar, Incisors		2^{nd} molar, PMs				3^{rd} Molar															
Bogin 1997	Infant				Childhood				Juvenile Girls**			Adolescence : 5-8 years after puberty									ADULT	
									Juvenile Boys**													
Panter-Brick 1998	Infant	Early Childhood					Late Childhood: Girls: 10-14**															
							Boys: 12 – 16**															
Baker et al. (2005)	Infant	Young Child						Older Child: Girl **				Adolescence: Girl										
								Boy**						Adolescence: Boy								
Buikstra & Ubelaker (1994)	Infant				Child									Adolescence								

*Blue: European Bioarchaeology, Green: Medical Anthropology, Red: Growth Events, Orange: Dental, Purple: American, Yellow: Behavioral

Stage 1: Infancy

In four of the aging schemes, the first year of life has been distinguished from the other early periods. In order to be consistent, this age group is referred to as Infant. It is during this time that the infant has the highest rate of postnatal growth and by the end of the first year it will have tripled its size and weight (Charlesworth 2010:222). An infant grows approximately 25 centimeters to 30 centimeters during the first year of life (Cameron and Bogin 2012: 25). This is also a period of development in motor skills and cognitive abilities. The infant will have progressed from limited muscle control to having the ability to sit up (approximately six months) and will eventually be able to stand (approximately nine months) (Charlesworth 2010). By the end of the first year, the infant will have the capability to move on its own. This is also the time in which the infant is completely dependent on the mother for breast milk, as well as the introduction of supplemental nutrition that should begin around 6 months of age (Bogin 1997:71). It is also a major period for dental development and formation (AlQahtani et al. 2010). The first deciduous teeth will have erupted around 6 months. The infant stage ends with the completion of the crown and eruption of the first deciduous molar.

The birth of a child in Ancient Egypt took place in a birthing room in the house or in a confinement pavilion that was built solely for delivery depending on the socioeconomic status of the family (Janssen and Janssen 2007). Images of these pavilions or rooms are seen throughout Egyptian illustrations and carvings. One such structure is depicted in the royal tombs at Tell el-Amarna. Akhenaten and Nefertiti's second daughter, Meketaten, is believed to have died in childbirth. She is depicted standing within a birthing pavilion while the royal family is in the posture of mourning just outside (Kemp 2012). In another image of mourning for Meketaten, a living child is being carried away by a nurse, which further supports the idea that she died during childbirth (Janssen and Janssen 2007).

For less wealthy individuals, delivery would have likely occurred in a room of their house. The room would have normally been decorated with depiction of the gods associated with fertility, pregnancy, children, and motherhood (Janssen and Janssen 2007). Evidence of these household gods have been found at Tell el-Amarna by archaeologists, which was originally surprising as it was believed that Akhenaten had prohibited the worship of any other god except for the Aten (Kemp 2012). For example, three scarab beads were discovered in a burial of a woman and child from the South Tombs Cemetery. Bes and Taweret have been identified as the gods depicted on the bottom of the beads (Kemp 2012: 276). Both gods represent patrons of childbirth, fertility, and home. This suggests that despite the major social and religious changes taking place during Akhenaten's reign, traditional childbirth rituals and customs are continuing to be performed by the people of Akhetaten.

The child would be given a name at birth usually by the mother, and it was then customary for the mother to breast feed her child (Janssen and Janssen 2007). Royal or wealthy families employed wet-nurses to feed their offspring. The medical literature is filled with prescriptions on how to increase the production of breast milk for women, as well as treatments for other breast issues (Strouhal et al. 2014: 182-185). The Ebers Papyrus and Papyrus Berlin 3038 focus on the care and issues associated with female breasts (Strouhal et al. 2014). The Ebers Papyrus deal specifically with the quality of breast milk, and increasing the production of milk by rubbing oil on the mothers back with the spine of a Nile perch (Strouhal et al. 2014). The transmission of infection and disease to the infant was a concern, and great care was taken to protect the health of the infant. However, despite these precautions it is estimated that every third or fourth child died during infancy in Ancient Egypt (Strouhal et al. 2014). Egyptians were well aware of the precarious nature of life, especially that of the young (Janssen and Janssen 2007).

Stage 2: Toddlerhood

The second stage that appears to be consistent with the other age groupings begins at the end of the first year and ends at the start of the third year of life. So not to confuse this period with later age categories, it is referred as the toddler stage or toddlerhood. The first year of life was centered on the development of motor skills and being able to walk (Cameron and Bogin 2012, Charlesworth 2010). The toddler continues to refine these skills along with fine motor skills, and by the end of this stage they will have the ability to run (Bogin 1997). During the toddler stage, there is also the acquisition of language and increased cognitive ability (Charlesworth 2010). By the end of the toddler stage, all deciduous teeth will have completed formation and all deciduous occlusal surfaces will be in the occlusal plane (AlQahtani et al. 2010).

During this period in the toddler's life, complementary feeding and weaning is also transpiring, as the mother is unable to produce enough milk to meet the demands of the growing child and thus dependency on solid food is increasing (Sellen 2006). Although human linear growth is declining and tapering off, locomotive abilities and brain growth are increasing rapidly at this time resulting in an increasing energy demand for the growing toddler. The human brain will have achieved 80% of its adult brain size by the age of three (Cameron and Bogin 2012). Even the healthiest mother is not able to meet the nutritional demands of the growing infant after six months without turning to supplementary foodstuffs (Sellen 2006). There is also the concern that the iron and other nutrients supplies of infants have been depleted by this time, and the mother is not able to transfer these nutrients through breast milk. Many human cultures have culturally adapted to attempt to meet the demands of the growing infant through the use of complementary feeding, as well as the use of other substitutions for breast milk (formula, cow/goat milk). Weaning is completed on average between 24 and 36 months in human populations (Bogin 1997:74). This is consistent with the weaning stage that is reported for ancient Egyptians in the Instruction of Ani that suggests that nursing lasted the first three years of life (Janssen and Janssen 2007:15).

Stage 3: Early Childhood

Similar to Bogin's evolutionary stages, the next age group is defined as the period between the ages of three and seven, and will be referred to as early childhood. This stage incorporates the developmental stage referred to as preschooler in child developmental psychology (Charlesworth 2010). This stage incorporates a great deal of socialization and learning (Charlesworth 2010:289, 555, 362). The end of the stage is marked with the completion of brain growth in weight (Bogin 1999: 76), along with the occurrence of the mid-childhood or juvenile growth spurt that occurs between the sixth and seventh year of life (Cameron and Bogin 2012). During this period of transition, we see the first loss of deciduous teeth and the eruption of the first permanent molars, all of which are events of the first active stage of dental development and eruption (AlQahtani et al 2010).

Egyptian children were expected to be functioning members of their households from a young age, as is still the case in Egypt today where children, as young as three are expected to assist with chores (Janssen and Janssen 2007). According to Janssen and Janssen (2007: 42), "boys run errands and feed and animals," while girls are expected to run "errands and get to perform small chores in the house." One New Kingdom proverb states "You shall not spare your body when you are young; food comes about by the hands, provisions by the feet" (Janssen and Janssen 2007). Depictions of children assisting with agricultural work is common in all of the periods of Egyptians history. Although childhood would not have been as care-free as that of modern western children, there was still time for play (Meskell 2005: 84). The identification of images depicting games being played by children, as well as the documentation of toys in the archaeological record suggest that this was also a time of explorative and interpretive social learning. Ball games, dancing, music, and swimming would have been common activities for these young Egyptians (Janssen and Janssen 2007; Meskell 2005).

Stage 4: Late Childhood

The fourth stage will be referred to as late childhood, and it includes individuals in the age range of seven to fourteen years. This is a period of very active dental development (AlQahtani et al. 2010). It begins at the end of the first active stage and includes the second active stage, which consists of the eruption of the remaining permanent teeth except for the third molars. During this time, third molars begin tooth crown formation. The late childhood age stage will end with the eruption and root completion of the second permanent molars. Puberty and the adolescent growth spurt also mark the end of this period (Bogin 1997). As previously mentioned, there are differences between the onset of puberty based on the individual's biological sex with girls being on average two years earlier than boys (Cameron and Bogin 2012). There is currently no method that can reliably identify the sex of a subadult skeleton (Lewis 2007). Fourteen was chosen as the point of transition for this analysis as both males and female will have reached puberty by this age.

At the approximate age of seven, young boys could have the opportunity to go to school to become a scribe or could have started formal training through apprenticeship (Janssen and Janssen 2007). It was also common for boys to begin assisting their fathers in their labor and learning their trade. There is very little evidence that girls received any formal education or training. The few cases appear to be mostly limited to royals or members of the wealthy class. The discovery of Mertitaten's palette in Tutankhamun's tomb suggests that Akhenaten's daughters may have been literate (Janssen and Janssen 2007: 71). Akhenaten's reign was possibly a time of increased responsibilities and learning for both sexes in Ancient Egypt.

Stage 5: Young Adult

There is no agreement among archaeological and historical researchers on when adulthood began in Ancient Egypt, and there is no evidence of an adolescent stage (Janssen and Janssen 2007). Adulthood could have begun at the end of puberty. This would be marked with the males going through the ritual act of circumcision or the beginning of menarche for young females. Janssen and Janssen (2007) present other evidence that suggest that adulthood began when an individual married or received their first independent appointment. This transition was probably not as socially fixed as other cultures, as there appears to be some flexibility in the exact age this conversion into adulthood occurs in Ancient Egypt. Due to the lack of agreement among Egyptologist and its significance as a human life history trait, the completion of puberty for both males and females is being used to mark the transition into adulthood for this dissertation. This period of "social maturity" is referred to as young adulthood and includes the age range of 15 to 25 years of age. During this time, growth is extremely reduced and almost complete (Bogin 1997, Cameron and Bogin 2012). Fusion of the secondary epiphyseal centers has commenced and in most cases finished (Cunningham et al. 2016). The complete fusion of the spheno-occipital synchondrosis has on average occurred, and the 3rd molar has in most cases erupted (Bogin 1997; Scheuer and Black 2004; AlQahtani et al. 2010).

Conclusion

This chapter provided a brief overview of the history and literature associated with the examination of children and childhood in the archaeological record. It also examined the different age categories, along with inconsistent use of terminology to refer to subadult skeletal remains. It identified consistent life stages between the various aging groups that have been utilized by researchers in previous archaeological and anthropological investigations of the past, as well as those used by other scientific fields. Based on the examination of the previous aging groups the following age stages were identified and will be implemented in the STC's comparative growth and health analysis in this study:

Infancy – Birth to 1 year

Toddlerhood – 1 year to 3 years

Early Childhood – 3 to 7 years

Late Childhood – 7 years to 14

Young Adult – 14 to 20 years

These groups were supported by evolutionary, cognitive and motor skill development, as well as dental formation and eruption schedules. Throughout the investigation, when possible information on Egyptian culture was included to help recreate and identify consistency or inconstancies within the general social context of Ancient Egypt, as information obtained on the specific cultural context of the Amarna time period is not always available. One of the limiting aspect of these new age groups was the inability to sex subadult skeletal remains (Lewis 2007). Difference in biological ontogeny and social status between males and females may affect the timing of these life stages. These variances due to difference in sex, as well as cultural contexts will need to be taken into account as possible causes for any inconsistencies or errors in the analysis of the South Tombs Cemetery and the comparative skeletal populations.

Chapter IV

Biocultural and Theoretical Frameworks

Osteological analyses of mortuary remains conducted prior to the 1980’s are considered more descriptive in nature, and have been criticized for employing little to no scientific theory in their interpretations of past populations (Buikstra 1977; Martin et al. 2013; Walker 2001; Zuckerman and Armelagos 2011). Processual archaeology provided a scientific framework focused on ecological explanations that allowed for the development of bioarchaeology, which was then able to combine human evolution and adaptation with archaeological remains for a more holistic understanding of the past (Armelagos 2003; Binford and Binford 1968; Martin et al. 2013). Since the 1980’s, bioarchaeology has employed a more interdisciplinary and cross-cultural approach to skeletal analyses allowing biological data to be interpreted within social and ecological contexts (Martin et al. 2013). According to Martin et al., “the linking of demographic, biological, and cultural processes within an ecological framework is essential for dealing with the kinds of questions that interest archaeologists and biological anthropologists today” (2013:10). The use of a biocultural approach in bioarchaeology has increased significantly since the 1990’s and has revolutionized the field by integrating social and biological theory into skeletal analyses (Zuckerman and Armelagos 2011). This chapter will discuss the biological and social theories that are used to interpret the growth and health data collected from the South Tombs Cemetery and the comparative samples within their unique ecological and cultural contexts. These theoretical approaches will assist in understanding the effects major social changes have on the over-all wellbeing of children through the analysis of the subadult populations analyzed in this dissertation.

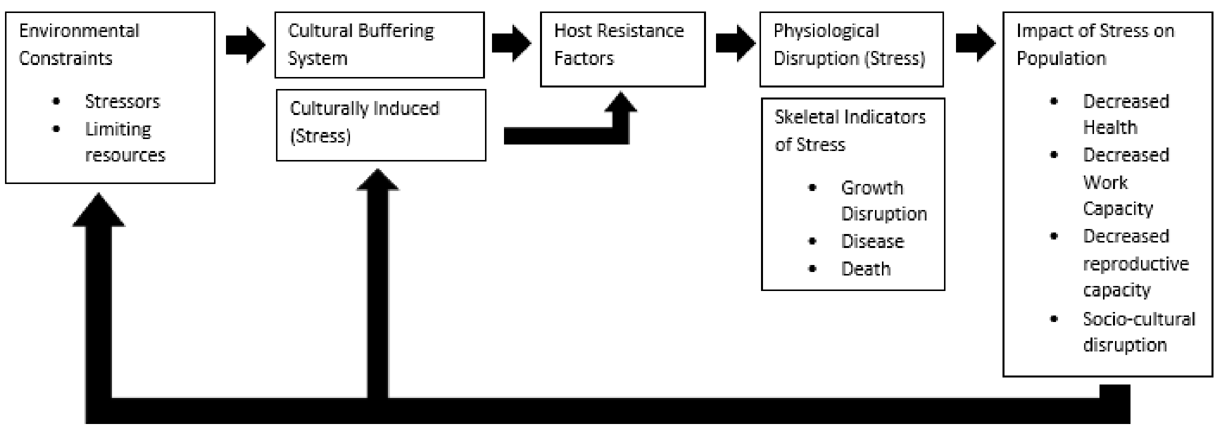
Biocultural Approach and Stress Model

The biocultural approach emphasizes that the human experience is a compilation of social, cultural, ecological, and biological environments that result in physiological responses by the individual (Buikstra 1977; Martin et al. 2013; Zuckerman and Armelagos 2011). Three primary components make up the foundation of bioculturally-oriented bioarchaeology. According to Zuckerman and Armelagos, these components include “the application of a population perspective; the recognition that culture is an adaptive force within human environments that is inextricably linked to biological adaptation; and the existence of methods for testing alternative hypotheses on the interaction between biological and cultural dimensions of the adaptive process” (2011: 21). Consideration is equally given to both cultural and biological explanations when accounting for the physical responses identified in skeletal remains (Martin et al. 2013). This requires a multidimensional approach in recreating the cultural and physical environments based on human remains and mortuary artifacts.

Stress theory is the basis for understanding the body’s physiological response to the cultural and physical environments (Martin et al. 2013; Forshee et al. 2010). Hans Selye was the first to define stress within a biological context in his short letter to *Nature* in 1936 (Szabo et al. 2012). His work would be the beginning of a massive amount of biomedical and psychological research conducted on the topic. Stress is now seen within a more holistic blend of social, psychological, biological, and behavioral interactions. These interactions can result in a physical or perceived disruption to homeostasis that result in physiological reaction by the body (Forshee et al. 2010).

The body can have both specific and non-specific reactions to various stress factors that can result in physical changes to the skeleton. Bioarchaeologists are able to identify skeletal lesions that can be caused by these specific and non-specific stress events during an individual's life. In order to study stress in past populations, bioarchaeologists must comprehend how the skeleton reacts to different types of stressors within the biological and cultural contexts. A biocultural model of stress is used as a framework to interpret the biological responses to both cultural and physical environments (Martin et al. 2013). Figure 1 is an example of a simple version of the stress model presented by Martin et al. (2013:11). In this model both ecological environmental factors, as well as cultural and physiological responses are taken in to account for a given population.

Figure 1: Biocultural model of stress recreated by the author from Martin et al. (2013: 11).



Environmental constraints focuses on the access to essential resources, as well as presence of ecological stressors that affect an individual's ability to respond and survive. For example, domesticated animals would provide a constant source of food for a society, but would be a source of bacteria that could result in infections and disease outbreaks. Access to large bodies of water are a source for fresh water for a human populations, but would have also been a breeding ground for mosquitoes that are vectors for diseases (e.g. malaria). The migration to a new settlement could result in additional environmental stressors not originally experienced by the immigrating population. Studies conducted on modern populations have demonstrated how foreign social and physical environments are affecting the quality of life of migrant groups living today (Hertz 1993; Xi 2014).

How a society culturally adapts to these environmental stressors is the next step in the biocultural model. Ideology, social organization, and technology act as buffering systems in which the environmental stressors filter through, and often times can assist with reducing the negative effects on the individual (Martin et al. 2013). Cultural traditions or custom, however, create their own stressors that affect the wellbeing of the practitioner. Large settlements and poor sanitation could be considered a cultural stressor, as it would result in the transmission of bacteria and other disease causing agents throughout the population leading to higher mortality. A positive cultural buffering for domesticated animals could be the separation of livestock from human living quarters, which would then limit the bacterial transmission between animals and humans. Traditional medicinal and care practices would play a role in how the patients are treated, but access to these would likely be limited based on socioeconomic status within their cultural group.

The factors that affect the individual's physiological response to stressors are directly tied to host resistance (Martin et al. 2013). Stressors will affect individuals differently depending on their overall health, as well as their age and sex at the time of the stress event. Infants and the elderly, who tend to have poor immune responses, will respond more severely to infection or disease (Baustian 2010; Bouquet-Appel and Masset 1982; Hoppa 2002; Wood et al. 1992). An individual with low socioeconomic status may not be able to obtain proper nutrition, which would then hinder the individuals overall health (Gravlee 2009). Host resistance is a dynamic quality that fluctuates throughout the individual’s life history. The individual’s physiological response is not only affected by the current state of their health, but also their health and life history. All of this affects their ability to respond to stress and return to homeostasis.

The manifestations of stress in the human skeleton is collected during the skeletal analysis of the mortuary remains, and are listed within the model as evidence of the body’s physiological responses. Numerous methods have been designed in bioarchaeology to provide evidence of the overall health wellbeing of people in the past (i.e. Brickley and Ives 2008; Buikstra and Roberts 2012; Buikstra and Ubelaker 1994; Katzenberg and Saunders 2008; Larsen 1997; Martin et al. 2013; Roberts and Manchester 2007). Stress markers are often considered as non-specific responses because the specific cause of the lesion is unknown, as multiple stressors can result in similar skeletal reactions (Martin et al. 2013). However, the lack of a specific diagnosis does not reduce the importance of these lesions as evidence of stress. From a population perspective, they provide significant information on severity, duration, and timing, as well as prevalence of stress episodes within a population and among different sociobiological groups.

The next step in the biocultural stress model is to link these factors and responses to the population as a whole. The impact of stress on the population is inferred from the evidence provided through the analysis of the individual skeletal remains. Environmental and cultural stressors can result in social modifications at the population level, such as warfare or disruption to political and economic structures (Martin et al. 2013). However, these population changes can result in environmental changes or require the creation of new cultural buffering to reduce their effects on the individual. According to Martin et al., “the feedback from box 5 back into boxes 1 and 2 represents the ways that cultural and population-level changes can further cause changes in the environmental (both the physical and the culturally constructed) systems” (2013:12).

The feedback loop allows the model to be as dynamic and complex as the researcher requires for their investigation making it a powerful tool for bioarchaeologists. However, theory is needed to interpret the information being presented in the biocultural model (Martin et al. 2013). Biological and social theory provides explanations as to why humans behave the way they do. The lack of theory in bioarchaeological investigations greatly reduces the relevance and significance of research, as well as limits explanations of life in the past.

Life History Theory

Bioarchaeology has been slow to include both biological and social theories in its interpretation of skeletal data when compared to other anthropological fields (Agarwal and Glencross 2011; Martin et al. 2013). Chapter 3 outlined and reviewed the use of social theory to identify children and childhood in the archaeological record, and resulted in the development socioculturally relevant age categories for this investigation. The study of subadult skeletal remains in bioarchaeology focuses on the essential biological concepts of plasticity, growth, and development. Various developmental approaches have been suggested in interpreting bone morphology, maintenance, and loss as adaptation to fluctuations in social, ecological and biological variables (Agarwal and Beauchesne 2011). This dissertation will combine a life history approach with gender theory to the interpretation of the subadult skeletal data from the South Tombs Cemetery.

Social and environmental conditions play a prominent role in sustaining or constraining growth and development. Every increase in size or height not only has its initial energy cost, but also the additional cost of maintenance until the death of the individual. It has long been held in biological anthropology that slower growth rates will be observed in poor living conditions, and vice versa (Stearns and Koella 1986). Better living conditions are associated with faster childhood and juvenile growth that is punctuated with an earlier juvenile growth spurt resulting in larger adults. Walker et al. (2006), however, challenged these simple explanations when they examined variations in body growth using cross-sectional height and weight velocities in 22 small-scale societies in an attempt to further explain relationships among life history traits in these populations. Although some of their data was incomplete due to recording methods by the ethnographic researchers, they were able to create a three-dimensional chart that showed the relationship that human growth and development had with juvenile survival (high/low), adult survival (high/low), and resource availability (high/low). They found that a greater risk of death caused by parasites and infectious diseases would result in faster growth and development. When the risk of death caused by disease was reduced and the chances of starving to death was increased then growth was delayed. Bioarchaeologist then have the ability to work backwards by using evidence of life history traits of a particular skeletal sample obtained from the archaeological record. The more information we are able to obtain about different life history traits from the skeletal sample, the more we can indirectly infer about morbidity, mortality, and fertility rates, as long as we remember that it is always possible for more than one optimal strategy to exist for a given environment.

Life history theory is the concept that scheduling and rates of key events that occur throughout the life of the organism are phenotypes that are undergoing selective forces throughout the organism's lifetime. Stearns (1992:10) states that, "life history evolution makes the simplifying claim that the phenotype consists of demographic traits – birth, age and size at maturity, number and size of offspring, growth and reproductive investment, length of life, death – connected by constraining relationships, tradeoffs…including those between current reproduction and survival, current reproduction and future reproduction, number, size and sex of offspring." Simply said, the goal of life history theory is to explain why different organisms exhibit different life cycles around the world.

Life history theory consists of two fundamental principles: natural selection and trade-off-time/energy (Paine and Hawkes 2006). Trade-off-time/energy refers to the allocation of energy or time between different life history traits. Life history traits are split into three categories: growth; reproduction; maintenance/repair of somatic cells. Organisms do not have an unlimited supply of energy or resources, and any energy obtained by the life form must be distributed between these categories in a way that maximizes the fitness of the organism. Any energy used in one area is now lost and unable to be used by another category or trait. An organism attempts to balance energy between the three categories during its life in order to increase its survivability and fitness.

In anthropology, life history theory has been used to study human physiological strategies and traits throughout our evolutionary history. Life history theory has focused on the development of these traits in our lineage and the plasticity of life history traits within the human species (Paines and Hawkes 2006). There are currently four life history traits that are unique to the human species: extended life span, midlife menopause, early age of weaning, and delayed maturation (Hawkes 2006). Modern human life history studies conducted on extant populations indicate variation in these regulatory phenotypic traits that allows human populations to adapt under periods of stress or change (Hill and Hurtado 1996). This has led to a recent emphasis on life history theory being applied in bioarchaeology through a demographic approach to understand how these traits have fluctuated over time and space (Paine and Boldsen 2006). It has been suggested that the application of life history theory could assist paleodemography with the problems currently affecting demographic populations in the past (Bouquet-Appel and Masset 1982; Hoppa 2002; Wood et al. 1992). Life history theory thus offers a theoretical framework that paleodemographers and bioarchaeologists can use to test hypotheses about past populations. Bioarchaeology provides a deep time perspective that is missing from modern studies as well as cross-cultural skeletal samples. Any study of life history strategies in modern humans is limited to the lifetime of the observer, as well as to the current climatic, social, and ecological environment the current population is experiencing.

Conclusion

In order to explain the life experiences of past populations, bioarchaeologists must rely on a multiple of lines of evidence. Skeletal biology and bioarchaeology methods provide the means to collect data through osteological analysis. The skeletal remains represent a physical manifestation of the biological and social life histories that have accumulated through the dynamic processes of maintenance and repair, as well as the growth and development of the individual. According to Oris et al. (2004:360), “Biological, environmental, economic, social, and cultural factors interact to influence the survival chances of the youngest members of society. Disease and malnutrition no longer are mere causes of death, but the consequences of an interaction between social and biological contexts.” This chapter demonstrates how a biocultural model of stress can be used as a tool in bioarchaeology to identify and organize influential factors that are affecting a given population. Life history theory, as well as the use of social theory can help interpret these relationships and their effect on a society. The biocultural approach in conjunction with life history theory is used in this investigation to examine what it was like to live and grow up at Akhetaten.

Chapter V

Archaeological Samples

The goal of this dissertation is to provide evidence of the health and wellbeing of Akhetaten's citizens through the comparison of the subadult skeletal remains from the South Tombs Cemetery, Tell el Amarna, to other cemeteries from periods of time during which major social, political and economic changes took place. This chapter will provide a brief description of the skeletal samples, as well as the historical and archaeological context of each site that will be utilized in this investigation. The sites were selected based on the social, economic, religious, and political context of their time periods, as well as the presence of subadult remains and the ability of the data to be accessed by the researcher. The comparative samples used in this research analysis include the HK43 cemetery from Hierakonpolis (Egypt), the African American cemetery from Cedar Grove (Arkansas), and the St. Martin's Churchyard from Birmingham (United Kingdom).

Sample Parameters

Due to the short occupation period of Akhetaten, only the subadults from the South Tombs Cemetery can inform us on what it was like to grow up during the reign of the pharaoh Akhenaten. Anyone older than seventeen years would not have been born and raised at Akhetaten. Therefore, this investigation only uses subadult skeletal remains that have a dental age less than 17.5 years of age and at least one complete long bone for growth and health analysis. Dental age had to be normalized for all the samples by using the same dental aging techniques. Dental age of the subadults from South Tombs Cemetery was estimated using the atlas of dental development published by AlQahtani et al. (2010). The comparative samples used other dental aging methods to estimate age for the subadults. These were re-aged by the author using the atlas by AlQahtani et al. (2010) to allow for comparison with the South Tombs Cemetery.

One of the ways that was suggested for dealing with the inaccuracies of aging methods is to use aging groups or “age indicator stages” instead of estimated chronological ages (Hoppa 2002). In chapter three, five age stages were identified to be used in this analysis to divide subadult individuals based on both social and biological life history traits. Individuals were placed into these five developmental age ranges for comparison based on their dental age: Infant (Birth-10.5 months), Toddler (1.5-2.5 years), Child (3.5-7.5 years), Juvenile (8.5-14.5 yeas), and young adult (15.5-16.5).

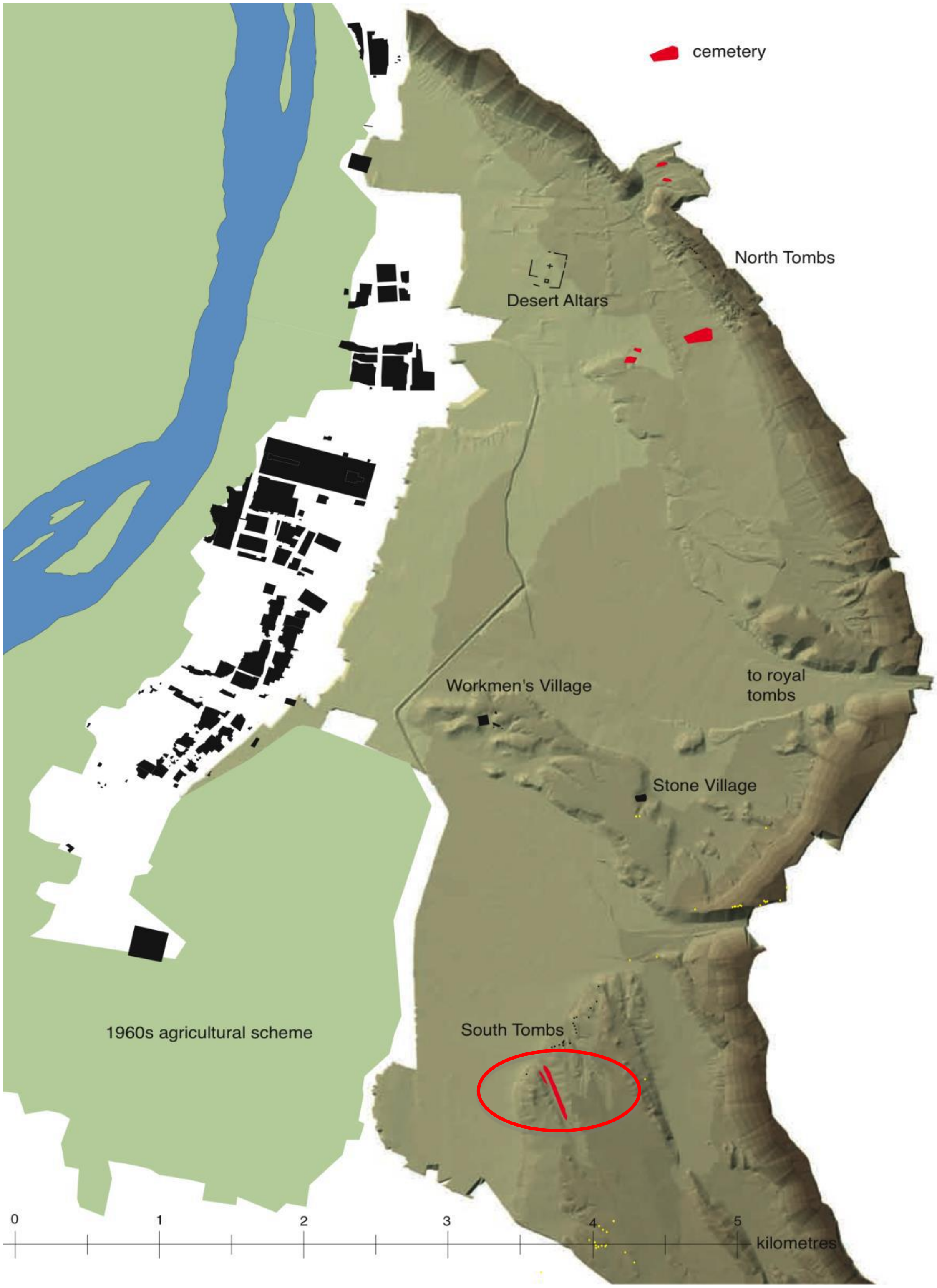
There is currently no accurate method to determine the sex of subadults that does not involve DNA analysis. In subadults, differences in skeletal maturation between the sexes can be as great as 2 years (Lewis 2007). DNA analysis is expensive, destructive, and often predicts a high percentage of females (Lewis 2007). No attempt was made to determine sex from the skeletal remains at this time and this, will be taken into account during analysis and when reaching any conclusions in this study regarding any developmental discrepancies.

South Tombs Cemetery, Tell el-Amarna, Egypt

This section will describe the archaeological investigation that have been conducted at the South Tombs Cemetery as the historical context surrounding the formation of the site was summarized in chapter two. The South Tombs Cemetery is one of four large cemeteries associated with the ancient city Akhetaten. The modern site of Akhetaten is known as Tell el-

Amarna, and its located in middle Egypt between Cairo and Luxor. Archaeological investigations have taken place at Tell el-Amarna since 1892; however, the first cemetery was not located until 2001 during Geographic Information System (GIS) surveys of the desert (Fenwick 2005, Stevens 2017). The cemetery was discovered in 2003 in a narrow *wadi* (a valley or streambed that is dry except for the rainy season) that runs behind Tomb 25 in the South Tombs group (Kemp et al. 2013). The location of the South Tombs Cemetery in relation to the city can be seen in Figure 3. Occasional floods have led to pottery, human skeletal remains, and other debris being washed away and left on the desert surface. In 2005, from March 7th to March 15th, a surface survey was conducted to collect surface scatter along the *wadi*. The majority of the pottery collected on the surface was from the 18th dynasty, corresponding with the habitation of the city, Akhetaten.

Figure 2: A map showing the location of the cemeteries at Tell el-Amarna adapted from B. Kemp, Amarna Project. The South Tombs Cemetery is circled in red.



Excavations of STC began in 2006 and were completed in 2014. Approximately 432 individuals were excavated during that time (Rose and Dabbs 2014). The bioarchaeological analysis is in the process of being completed. The majority of the skeletons excavated were wrapped in textile, laid out in a supine position, and placed in burial containers. Burial containers can vary, but the majority of the individuals were buried in plant branch or palm frond mats that were bound by ropes. A very small number of individuals were found in more elaborate containers, such as wooden coffins, both plain and decorated. Grave goods are rare and are usually remains of pottery vessels (Kemp et al. 2013). One hundred seventy two of the individuals of the estimated 432 individuals recorded were subadults. One hundred two subadult individuals are suitable for the growth and health analysis. They ranged in dental age from 4.5 months to 16.5 years.

HK43, Hierakonpolis, Egypt

Hierakonpolis is the modern site of Nekhen (Van de Mieroop 2011), which is located about 650 miles south of Cairo. Hierakonpolis is Greek for "the city of the falcon" and was once the cult center for the falcon god, Horus (Van de Mieroop 2011:25). The Predynastic site dates to the Naqada IC to the Naqada IId periods (c. 3900-3100 BCE), which was of a time of unification and the development of the Egyptian State (Kuznets 1966; Kemp 1989). According to Van de Mieroop, "Not only was the political model of a united Upper and Lower Egypt established, but also the ideals of kinship as well as the means of glorifying and supporting the king" (2011:29). This was a period of innovation with the development of writing, art, and architecture, as well as a time of prosperity and growth with the gradual unification of Upper and Lower Egypt. Regional social, economic, and political foundations would begin to form and would eventually become the base of the Egyptian society for years to come. The first evidence of divergent socioeconomic status in Egypt is based on inconsistencies in grave good assemblages that appeared during this period (Van de Mieroop 2011). These distinctions in burial goods increase over time demonstrating the increasing stratification of wealth culminating in the developing Egyptian society. Farming methods and techniques using the Nile River were established at this time, with the new elite class gaining power through trade outside of the Nile River valley.

Hierakonpolis is believed to have been a regional capital and major population center during the Predynastic period (Hoffman 1982; Wilkinson 1999). Evidence for settlements date as far back as 4000 BCE in the north (Hoffman et al. 1986). These early settlers are believed to have been farmers and pastoralists with a heavy reliance on cereal agriculture (Batey 2012; Wengrow 2006). Population growth was gradual and at its peak estimates have been as large as 10,000 people (Hoffman 1982) and as small 1500 to 2000 (Hassan 1984). However, despite this being a regional center, researchers argue that there is little evidence that suggest that migration was a huge factor in the rise in population (Batey 2012; Irish 2006; Zakrzewski 2007).

The first archaeological excavations began in 1897 at Hierakonpolis and continue to this day. HK43 cemetery is one of three cemeteries located at Hierakonpolis and belongs to the working class of the city. HK43 has been classified as a working class cemetery based the lack of burial goods, density, and location in the city (Dougherty and Friedman 2008; Friedman et al. 1999; Gamza and Irish 2010). The portion of the cemetery that was excavated likely spans about 300 years within the Naqada IIA–C (ca. 3600–3200 BC) (Dougherty and Friedman 2008; Friedman et al. 2002;). The individuals buried in the HK43 cemetery would have been affected the most by the economic, political, and social changes taking place during this period of unification (Batey 2012). Excavation of HK43 cemetery took place between 1996 and 2004 by Dr Renee Friedman, at which time 453 discrete burials containing 490 individuals were excavated (Gamza and Irish 2012). Previous skeletal analyses conducted on the HK43 population have concluded that the people of Hierakonpolis were generally very healthy with low indicators of stress, infection, and disease (Greene 2006; Kumar 2009; Zabecki 2009). Of those excavated, 137 are considered subadults. Only 35 individuals ranging in age from 7.5 months to 15.5 years are suitable for the growth and health analysis.

Cedar Grove Cemetery, Arkansas

Cedar Grove Cemetery was first discovered in the spring of 1980 when skeletal remains were found eroding from the bank of the Red River (Davidson et al 2002; Rose 1985). Lafayette County is located in southwest Arkansas in the Red River Valley. The Red River dominated the life of the local communities (Watkins 1985). The clearing of the Great Raft of the Red River between 1830 and1838 provided a reliable means for transporting and shipping crops and goods from and to the region. A variety of food and grains were grown in the region but cotton was the primary commercial crop. Due to high waters and record floods, the river also presented a threat to the local community. It was a deadly flood in 1927 that resulted in cotton being replaced by soybeans, rice, and cattle.

The Cedar Grove Cemetery is located on the old Barnett Place, which was a large slave-holding plantation established by Thomas M. Barnett in 1834 (Watkins 1985). As was common in southwest Arkansas, the Barnett plantation was owned by an absentee proprietor, who left daily operations and management of the estate to hired overseers (Taylor 1958; Taylor 1959). The plantation is believed to have originally been a stock-raising operation as little agriculture production was reported as having been sold during Barnett's ownership. The plantation consisted of 600 improved acres with 65 slaves in 1850, and the following year Barnett would give control of the land to his son and son-in-law. The property would then proceed to exchange hands for the next couple of years until eventually begin sold to F.W. Armor in 1862 and then the Sentell family in 1963. F.W. Armor's slaves and the freedmen who worked for the Sentell property in 1865 are believed to have established the original community surrounding the Cedar Grove site. However, it is possible that the cemetery could have been in use as early as 1834.

In 1860, Lafayette county reported that of the 8,464 people residing in its borders of which 4,311 were slaves (Watkins 1985). Lafayette's average slave holding was 15.9 slaves per owner compared to the Arkansas average of 9.6 slaves per owner (Taylor 1958). Many slaves toiled as field hands, or worked in households performing menial labor (Watkins 1985). It was also common for the slaves to be hired out to assist with fixing local infrastructure, like roads and river levees.

Major social, political, and economic changes were taking place throughout the Southern United States after the Civil War. Racially motivated crime was particularly high, and segregation was being heavily implemented during this time. For the local African-American community of Lafayette County this period of changes was riddled with uncertainty and marginalization (Watkins 1985). Former owners wanted to reestablish workforces and get back to business with as little change as possible. The freed slaves wanted to restore their families, obtain land, and benefit from their newfound freedom. The implementation of a contract labor system in 1862 and the practice of sharecropping in 1865 led to most laborers becoming dependent on landowners and unable to purchase their own property.

Excavation began on June 16, 1982 and was completed by July 2, 1982. The cemetery was associated with the Cedar Grove Baptist Church, which was and continues to be, an important part of the African-American community in this area. The Steele Township which included the Cedar Grove community in 1900 reported having a population of 854 people – 741 Black (87%) and 113 White (13%) (U.S. Census 1900: Lafayette County reported in Watkins 1985). Unlike other southern states, Arkansas had a very strong missionary presence in the southwest region that took great interest in converting slaves to the Christian faith (Watkins 1985). The church was established in 1881 and the original church building associated with the cemetery burned down in 1924. The church was rebuilt in another location but a second fire took place in 1931, which was when the majority of the church records were destroyed. Eighty individuals were excavated and analyzed from the Cedar Grove cemetery, and excavators estimate that this was only 28% of the total cemetery population (Rose 1985). The mortuary hardware associated with the exhumed bodies date the excavated burials between 1900 and 1915 (Davidson et al. 2002). Forty-four of the exhumed individuals are subadults. Twenty-nine individuals are suitable for this analysis, ranging in age from 1.5 months to 12.5 years.

St. Martin's Churchyard, Birmingham, United Kingdom

St. Martin's Churchyard is associated with the St. Martin's church located in Birmingham, West Midlands, England. The current building was constructed in 1872 in a Gothic style architecture, but a house of worship has existed in this location since the 12^{th} century making St. Martin's the oldest church in Birmingham (Buteux 2006). St. Matin's Church is one of the few iconic buildings remaining from the Bullring, a marketplace place that dates back to 1166 when the city received official permission to open its own market (Buteux 2006; Emery et al. 2006). According to the Birmingham Alliance, "throughout history Birmingham had been a leading centre of trade and market innovations" (Emery et al 2006: X). The late 18th and early 19th century was a period of rapid urbanization resulting from the Industrial Revolution in England and had many health consequences for the people living during this time (Mays et al. 2008; Mays et al. 2009). Poor sanitation, pollution, overcrowding, and inadequate or contaminated food supplies led to high mortality rates in these urban areas. This was a period of rapid economical and social change that took place in England making it an ideal comparative population for Tell el-Amarna.

The West Midlands were at the center of the Industrial Revolution and Birmingham was a significant center of manufacturing during this time (Adams 2006). Metal working (Iron, brass, and steel), butcher shops, tanners, glass makers, shopkeepers, and innkeepers are just a few of the different types of manufacturers and services that were being provided by the large market area just north of St. Martin's Church. One Soho Manufactory of Mathew Boulton had over 1000 workers, but small family oriented workshops were more common in the area (Adams 2006). The Bullring was also a major cattle market for the regions, which may have been the reason for its name. Cattle, horses, and sheep were all sold in the market area, along with produce, linen, wool, and other goods.

With the increase in demand for labor and goods, Birmingham had a significant increase in population size during the 19th century. In 1801 the population was 60,822 and grew to 138,215 with the immigration of workers and their families to the booming industrial town (Adams 2006). The expanding population led to rapid constructions of tenant buildings in the district, which increased the problems of overcrowding, pollution, violence, and crime in this area. Long working hours in dangerous workshops or manufactories were a common condition of daily life in Birmingham.

The St. Martin's Churchyard was expanded multiple times in attempt to deal with the demand of the ever-growing population. In 1807, a separate two and half acre parcel of land was purchased on Park Street in hopes of alleviating the issue with overcrowding of burials in the churchyard (Adams 2006). However, people saw this location as being undesirable and an indication of low socioeconomic status due to its distance from the church and the alter. In 1810, the churchyard had to be expanded in the north, which is where a number of the burials excavated in 2001 were located. Demands and pressure on the churchyard would not be reduced until 1873 when the Secretary of State officially banned the practice of burials at churches, with only a few exceptions (Adams 2006). Thus, the majority of burials from 1873 onward occurred in council owned cemeteries located elsewhere in city.

A total of 857 individuals were excavated in 2001 and date from AD 1720 to AD 1863. There were 148 subadults that were identified during skeletal analysis. The majority of the population was buried in wooden coffins with metal fittings in earth cut graves (Buteux and Cherrington 2006). Many of these graves were overlapping and intercutting. There were 128 subadults buried in earth cut graves that were excavated. Unfortunately, no identification of individuals in the earth-cut burials could be made as the coffin plates had become unreadable due to corrosion of the metal (Buteux 2006). A small number of individuals were buried in more elaborate coffins and placed in family burial vaults. Attempts have been made to identify the individuals using church documents. There were 20 subadult individuals identified from burial vaults. Only 92 individuals of the total 148 subadults are suitable for the growth and health analysis. They range in age from 1.5 months to 16.5 years.

Sample Distributions

Table 2 shows the age group distributions, along with percentage of total populations for STC sample and each comparative sample. Despite the differences in sample size between STC and HK43, both Egyptian samples were represented with similar proportions across all age groups. This is not the case for the Cedar Grove Cemetery and the St. Martin's Churchyard subadult samples. Both of those cemeteries show a higher percentage of infants in their mortuary samples when compared to the two Egyptian samples. The United Nations (1955) describes a normal demographic profile as having the highest mortality at birth, which is then followed by a rapid decline in mortality. The minimum mortality rate should be around 12.5 years old, which should then be followed by a slow, gradual increase in mortality with age. The non-Egyptian samples both have a higher percentage of infants represented. The Cedar Grove has the most normal demographic profile with the infant stage being the most represented and the rapid decrease in the number of subadult represented as age increases. While St. Martin's Churchyard has a higher percentage of infants there is little decline in representation with aging. The STC and HK43 samples both have a higher percentage of late children (dental ages 7.5 years to 14.5 years) when compared to the other samples. This divergence may represent a higher infant mortality in the two non-Egyptian samples, or a difference in burial practices between the culturally diverse populations. It is possible that the infants in the Egyptians populations were being buried in a separate location from the rest of the populations. Infant and fetal remains are sometimes seen as "non-human" in some social or cultural groups, and therefore, are not always associated with adult mortuary complexes (Janssen and Janssen 2007; Scott 1999). Infant and fetal remains have been found under the floors of Ancient Egyptian houses, and Egyptian cemeteries that consist of only subadult remains have been discovered (Janssen and Janssen

2007).

Table 2: Age Group distribution for comparative samples for growth and health analysis

Age Groups	*STC*	*%*	*HK43*	*%*	*CGC*	*%*	*SMC*	*%*
Infant	*12*	*12%*	*3*	*9%*	*14*	*50%*	*26*	*28%*
Toddler	*22*	*22%*	*9*	*26%*	*5*	*18%*	*23*	*25%*
Early Child	*30*	*29%*	*9*	*26%*	*4*	*14%*	*23*	*25%*
Late Child	*31*	*30%*	*11*	*33%*	*5*	*18%*	*18*	*20%*
Young Adult	*7*	*7%*	*2*	*6%*	*0*	*0%*	*2*	*2%*
Total	*102*	*100%*	*34*	*100%*	*28*	*100%*	*92*	*100%*

Conclusion

This chapter provides a summary of the historical and archaeological contexts of the comparative samples used in the growth and health analysis of the South Tombs Cemetery. It has shown the unique cultural, environmental, and biological conditions in which these subadults lived and died. All osteological samples utilized in this investigation derive from populations undergoing socio-cultural changes and pressures, allowing for a biocultural comparison of childhood health under stress. The contextual information in this chapter, along with the skeletal evidence discussed in the following chapters are used in chapter eight to create the biocultural models of stress for each archaeological site.

Chapter VI

Childhood Growth: Methods and Analysis

Growth is an examination of any change in size that occurs during the maturation of an organism. The final achieved growth of an individual represents an accumulation of various genetic, environmental, and social factors that can retard or accelerate the rate of growth (Lewis 2007). Growth status is considered a sensitive indicator of the general health and well-being of a society, and any changes in physical and social environments can result in fluctuations of growth in the maturing child (Cameron and Bogin 2012; Bogin 1999; Johnston and Zimmer 1989; Tanner 1990). According to Lewis, "studies of past childhood growth have been used to provide valuable information on nutritional stress, secular trends, prolonged skeletal growth and delayed maturation" (2007:60). A number of growth studies have been been conducted on archaeological samples around the world (i.e. Alfonso-Durruty 2011; Armalegos et al. 1972; Batey 2005; Goode et al. 1993; Good-Null 2002; Hoppa 1992; Hoppa and Gruspier 1996; Hummert and Van Gerven 1983; Jantz and Owsley 1984; Kaczmarek 2012; Lewis 2007; Mays 1995; Mays et al 2008; Mays et al. 2009; Miles and Bulman 1995; Saunders et al. 1993; Sciulli 1994; y'Edynak 1976). However, there have been few growth studies conducted using Egyptian skeletal samples in bioarchaeology (i.e. Armalegos et al. 1972; Batey 2005; Kaczmarek 2003; Kaczmarek 2012; Wheeler 2009). The goal of this chapter is to examine the longitudinal growth of subadults from the South Tombs Cemetery (STC) by comparing it to the HK43 cemetery (HK43), the St. Martin's Churchyard (SMC), and the Cedar Grove Cemetery (CGC) skeletal samples in order to expand the current literature and data on childhood growth in Ancient Egypt and past cultures.

Methods and Samples

Growth will be assessed using long bone lengths in relation to standardized dental age and bio-cultural life stages. Dental age was used as the constant rather than long bone growth as environmental effects have less impact on dental development (Cardosa 2007). This allows researchers to identify whether an individual is meeting the expected standard long bone length for a given age when the two are compared. Dental age was normalized for the STC by using the atlas of dental development published by AlQahtani et al. (2010). All comparative subadult skeletal samples were re-aged using the same atlas for comparability.

All long bone measurements were taken following the subadult measurement methods outlined by Standards (Buikstra and Ubelaker 1994). The maximum diaphyseal length of long bones will be used as the dependent variable in this analysis (humerus, radius, ulna, femur, tibia, fibula). Measurements from the left elements were used when present and complete. In cases when the left side was unavailable, the measurement of the right side was substituted.

Growth was assessed by calculating the ratio of achieved long bone lengths to the Maresh standard (δlmean values) as outlined by Goode et al. (1993). Goode et al. (1993) developed this method as a way to combat the issue of poor skeletal samples, which makes it ideal for this investigation due to the small sample sizes of HK43 and CGC. The method allows for the growth of different skeletal elements to be compared at once, which increases the number of individuals that can be used in the analysis. Long bone measurements were standardized using the mean long bone length of the Maresh Standard (Scheuer and Black 2004). Diaphyseal length of each long bone was divided by the corresponding standard for their age to calculate single long bone ratios (δli). Mean long bone ratios (Individual δlmean) were then calculated for each individual that was represented by more than one skeletal element. Age mean long bone ratios (Age δlmean) and Age group mean long bone ratios (Age-Group δlmean) were calculated for each dental age and age group. Due to the differences in growth rates and timing of growth events between different long bones reported by Sciulli (1994), mean ratios were calculated for each long bone (Bone δlmean). Ratios from the sample growth populations were then compared to each other.

In the original Goode et al. (1993) method having an equal to or greater than one long bone ratio ($\delta li \geq 1$) indicated that the long bone reached or exceeded the standard for the given dental age. If the value is below one ($\delta li<1$), than the individual did not reach the standard for their age. However, one of the concerns with using ratios is the distortion of calculated means caused by ratio values greater than one. Any value greater than one will cause any mean values to be skewed. In order to reduce the effects of ratio values greater than one, the data was log transformed. This resulted in the line of unity equaling zero instead of one. A negative value indicates that the bone did not meet the standard, where as positive values would indicate a bone that exceeded the standard for their age.

Growth Results

South Tombs Cemetery (STC)

Figure three and four are scatter plots of 102 individual δlmean values calculated using male and female Maresh standards for the STC. Individual δlmean values plotted in figure 3 shows that 90.3% of the growth sample falls below the line of unity for the male Maresh standard and that 57.3% of the subsample were even poorer falling below -0.05. This indicates that the subadults and the young adults from STC were not reaching the male standard for long bone length for their ages suggesting poor achieved-growth in the majority of the population.

The STC has nine individuals that are above the line of unity using the male Maresh Standard, which means only 9.7% of the STC sample met or exceeded the growth standard for their age. Individuals at or above the line of Unity for the male Maresh Standard were only found in 4 dental ages: 4.5 months, 7.5 months, 1.5 years, 5.5 years, and 6.5 years. The majority of individuals is in the infant age group and had a dental age of 4.5 to 7.5 months. This suggests that the subadults from the STC had started life with a normal growth rate and that up to the age of 7.5 months were achieving the expected long bone lengths for their age groups based on the male Maresh Standard. When the female Maresh standards are used to calculate the individual δlmean values there is a slight fluctuation in the percentages. Figure four shows that 89.3% of the growth sample falls below the line of unity for the female Maresh standard and that 46.6% of the subsample were even poorer falling below -0.05. Only one additional individual (7.5 months old) reached the line of unity when using the female Maresh Standards rather than the male standards.

Figure 3: South Tombs Cemetery individual δlmean values and age δlmean values plotted for the male Maresh Standards.

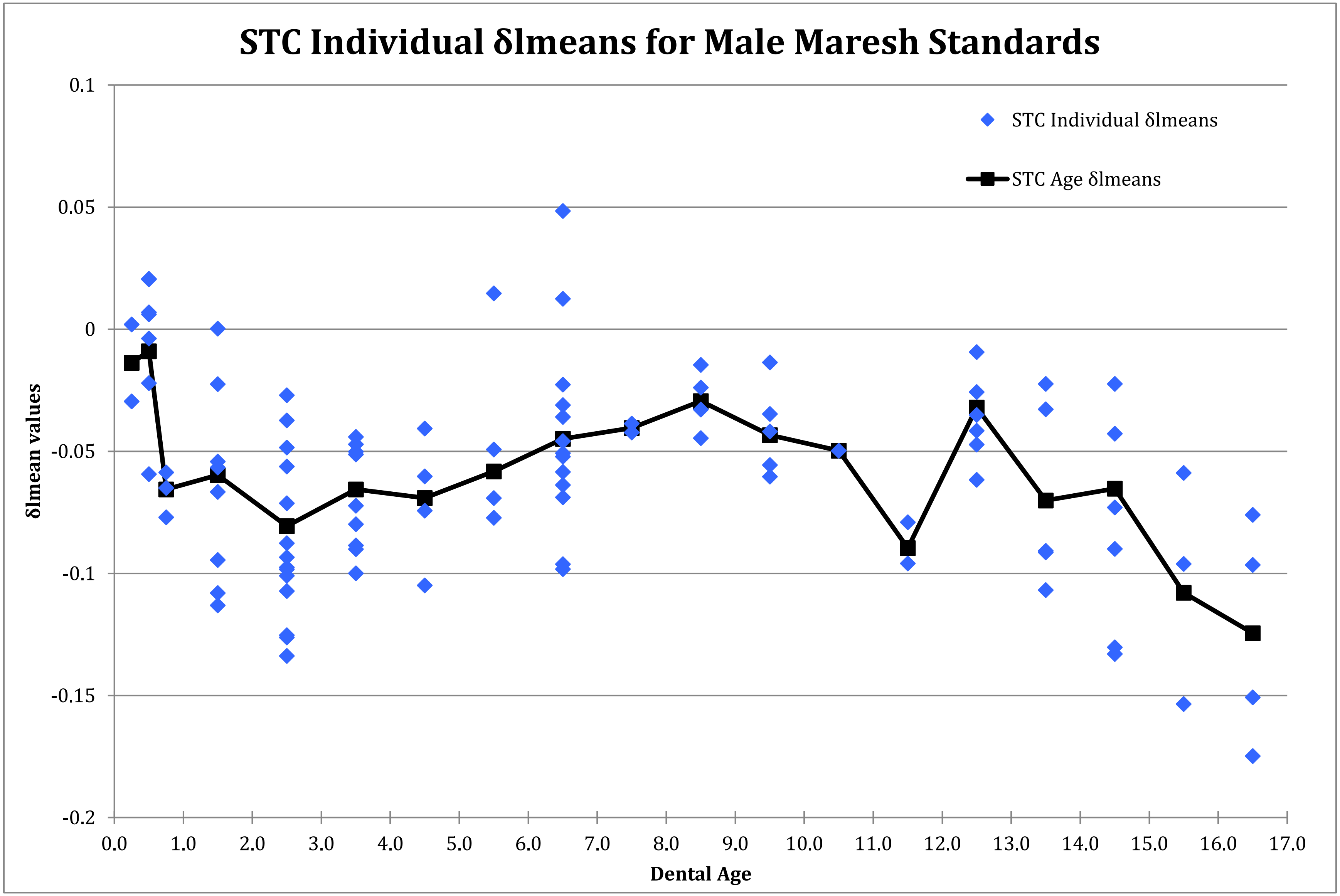
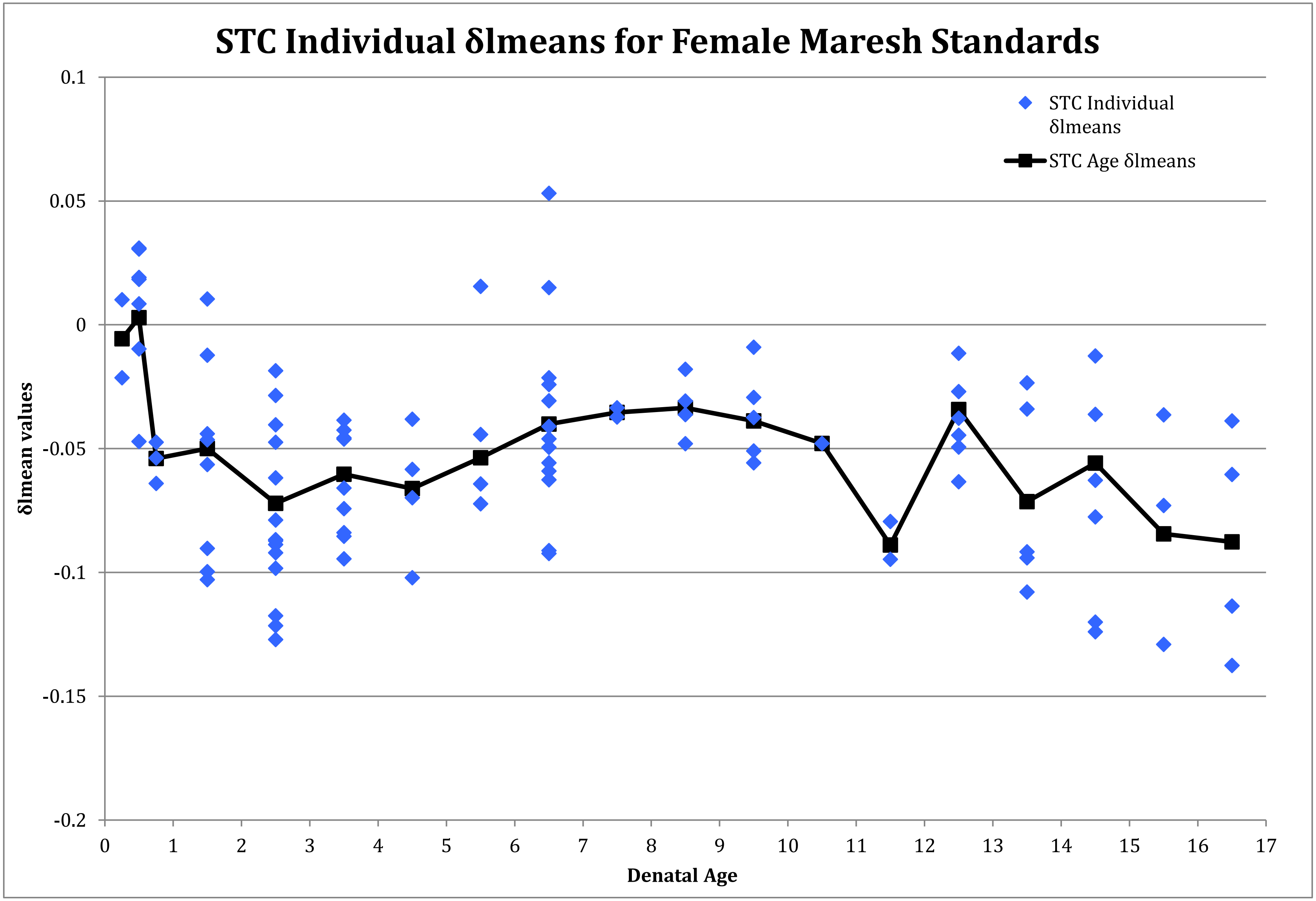
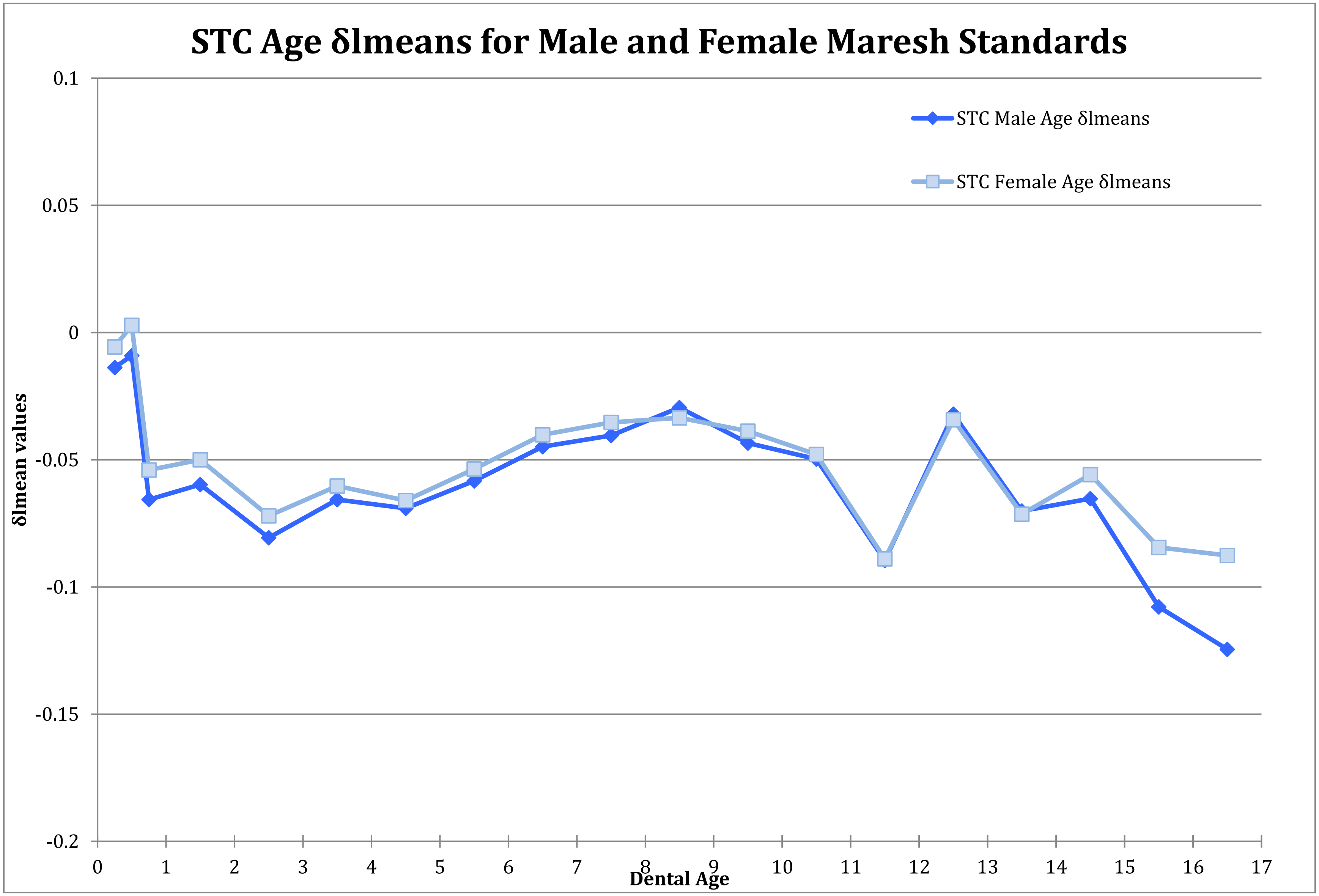


Figure 4: South Tombs Cemetery individual δlmean values and age δlmean values plotted for the female Maresh Standards.



STC male and female age δlmean values were also calculated for each dental age and were graphed in a trend line on figures three and four. None of the male age δlmeans for each age fall above the line of unity, and instead appear to fluctuate above or below the value -0.05. The only time the male age δlmean come close to the line of unity is during the first 7.5 months of life in both graphs, which is due to the higher percentage of individuals that were at or above the line unity in these ages. The female age δlmean does exceed the line of unity at 7.5 months, which suggest that for the first few months of life the infants of STC were reaching their growth expectations. The male and female age δlmeans for the STC are plotted together in figure 5. Although the female age δlmeans tend to be slightly higher, there is no significant difference between the male and female age δlmeans, except at the ages of 7.5 months (Independent Sample t test, p value = 0.0044) and 16.5 years (Independent Sample t test, p value = 0.0162). The male age δlmeans does have a greater decline when compared to the female age δlmeans after the age of 14.5 years, which is consistent with the onset of puberty for males (Cameron and Bogin 2012). This is when we should expect to see the greatest difference in sexual dimorphism between the sexes, which may account for this divergence. However, both male and female age δlmean values for these ages are well below of the line of unity. Whether these individuals are considered male or female, they are consistently not reaching their growth expectations for their dental ages based on the Maresh Standards.

Figure 5: South Tombs Cemetery age δlmean values plotted for male and female Maresh Standards.



Tables three and four consists of the percentage of individuals from the STC growth sample that are above and below the line of unity for each dental age, as well as percentage of individuals with an Individual δlmean values above and below -0.05. Table three δlmean values are calculated using the male Maresh Standards, and table four δlmean values are calculated with the female Maresh Standards. There are very little differences between the two tables. A pattern appears in the values that show periods in which individuals were more likely to have poorer achieved-growth than compared to the other dental age periods. Infants from the STC show an achieved-growth consistent with the Maresh Standards during the first 7.5 months of life. Young subadults from 10.5 months to 6.5 years were more likely to be more than 5% below the line of unity, indicating poor achieved-growth among these dental ages. Subdaults reaching the dental age of at least 7.5 years to 12.5 years show a better achieved-growth than their younger counterparts with the exception of the 11.5 year olds. Achieved-growth during the later years and into young adulthood (13.5 years to 16.5 years) is again poor compared to the earlier dental age group (7.5 years old to 12.5 year olds). Although there are differences between table three and four, both were still more likely to be less than -0.05 for their δlmean values indicating poor achieved growth for individuals with these dental ages. This shows that the growth disruptions were not consistent throughout the life history of the population and that there must have been periods of great stress during childhood that resulted in the delay, or stunting of growth in the majority of the STC subadults. The two periods of stress identified in the STC sample are from 7.5 months to 6.5 years of age and from 13.5 years to 16.5 years of age.

Table 3: Percentage of individuals from the STC growth sample above and below the line of unity, as well as less than and greater than -0.05 for the male Maresh Standards. The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (<Line of Unity)	Greater than 0.0 (>Line of Unity)
1.5 m	0				
4.5 m	2	0%	100%	50%	50%
7.5 m	7	14%	86%	43%	57%
10.5 m	3	100%	0%	100%	0%
1.5 yrs	8	75%	25%	87%	13%
2.5 yrs	14	79%	21%	100%	0%
3.5 yrs	9	78%	22%	100%	0%
4.5 yrs	4	75%	25%	100%	0%
5.5 yrs	4	50%	50%	75%	25%
6.5 yrs	13	54%	46%	85%	15%
7.5 yrs	2	0%	100%	100%	0%
8.5 yrs	4	0%	100%	100%	0%
9.5 yrs	5	40%	60%	100%	0%
10.5 yrs	1	0%	100%	100%	0%
11.5 yrs	2	100%	0%	100%	0%
12.5 yrs	6	17%	83%	100%	0%
13.5 yrs	5	60%	40%	100%	0%
14.5 yrs	6	67%	33%	100%	0%
15.5 yrs	3	100%	0%	100%	0%
16.5 yrs	4	100%	0%	100%	0%

Table 4: Percentage of individuals from the STC growth sample above and below the line of unity, as well as less than and greater than -0.05 for the female Maresh Standards. The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (<Line of Unity)	Greater than 0.0 (>Line of Unity)
1.5 m	0				
4.5 m	2	0%	100%	50%	50%
7.5 m	7	0%	100%	28%	72%
10.5 m	3	67%	33%	100%	0%
1.5 yrs	8	50%	50%	87%	13%
2.5 yrs	14	71%	29%	100%	0%
3.5 yrs	9	78%	22%	100%	0%
4.5 yrs	4	56%	44%	100%	0%
5.5 yrs	4	50%	50%	75%	25%
6.5 yrs	13	38%	62%	85%	15%
7.5 yrs	2	0%	100%	100%	0%
8.5 yrs	4	0%	100%	100%	0%
9.5 yrs	5	40%	60%	100%	0%
10.5 yrs	1	0%	100%	100%	0%
11.5 yrs	2	100%	0%	100%	0%
12.5 yrs	6	17%	83%	100%	0%
13.5 yrs	5	60%	40%	100%	0%
14.5 yrs	6	67%	33%	100%	0%
15.5 yrs	3	67%	33%	100%	0%
16.5 yrs	4	75%	25%	100%	0%

HK43 Cemetery

Figures six and seven are scatter plots of individual δlmean values for the HK43 cemetery sample. Figure six calculated the individual δlmean values using the male Maresh Standards, whereas figure seven used the female averages. The HK43 has seven individuals that are above the line of unity for the male Maresh Standrads, which translates to 20.6% of its population being at, or above the line of unity at the time of their death. These seven individuals were meeting, or had exceeded the growth standard for their age. These individual values were distributed across the following dental ages: 7.5 months, 1.5 years, 6.5 years, 7.5 years, and 11.5 years. The age distribution of these individuals is similar to that seen at the STC growth sample, except that the HK43 cemetery has late children that are meeting the standard of growth for their dental age suggesting better achieved-growth among the older subadults in this skeletal population. The individual δlmean values for the HK43 indicate that 79.4% of the subsample falls below the line of unity and that 38.2% of the subsample is below -0.05. Figure seven shows that 76.5% of the growth sample falls below the line of unity for the female Maresh standard and that 38.2% of the subsample were even poorer falling below -0.05. Only one additional individual (9.5 years) reached the line of unity when using the female Maresh Standards rather than the males. Although a large majority of the population is falling below the standard for dental age, there are a significantly greater number of individuals above -0.05 for the HK43 cemetery sample when compared to the STC sample using the male Maresh Standard (Fisher's Exact Test, p value = 0.0492). There is no significant differences when using the female Maresh Standard (Fisher's Exact Test, p value = 0.4317). This suggests that the subadults from HK43 demonstrated better overall achieved growth than the subadults from the STC. However, both skeletal samples are majoritively not meeting the expected growth standard for their dental ages.

Figure 6: South Tombs Cemetery individual δlmean values and age δlmean values plotted for the male Maresh Standards.

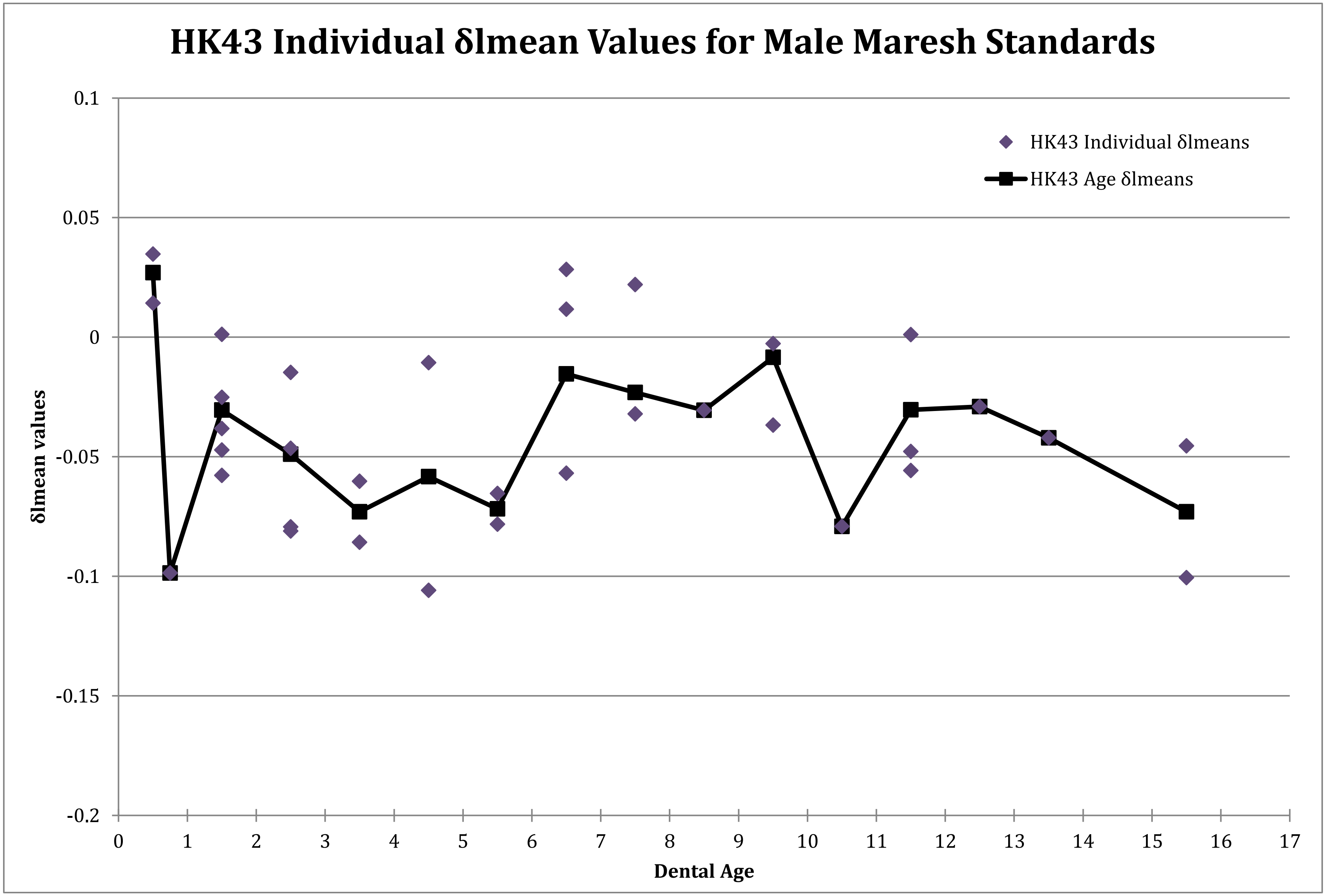
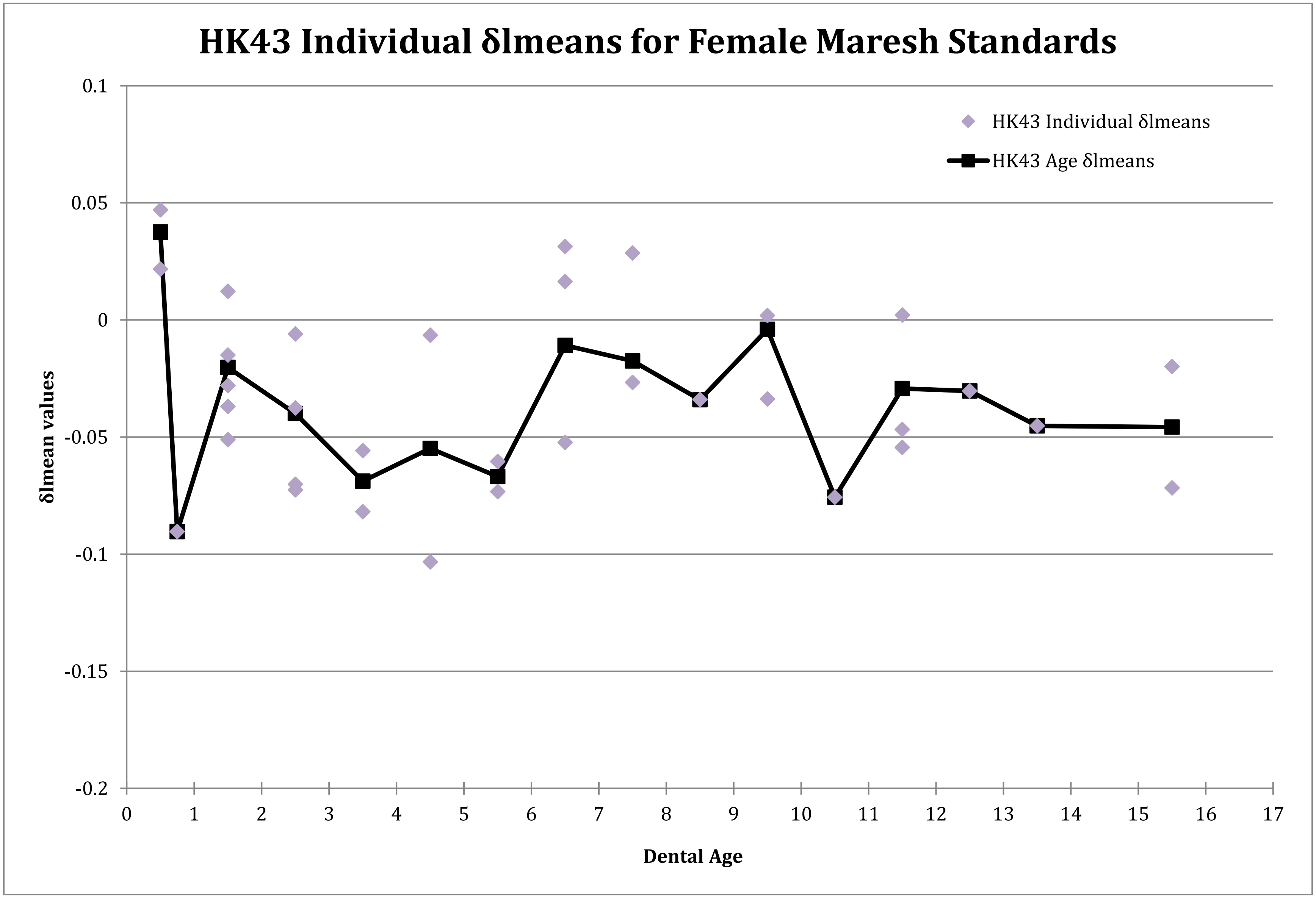
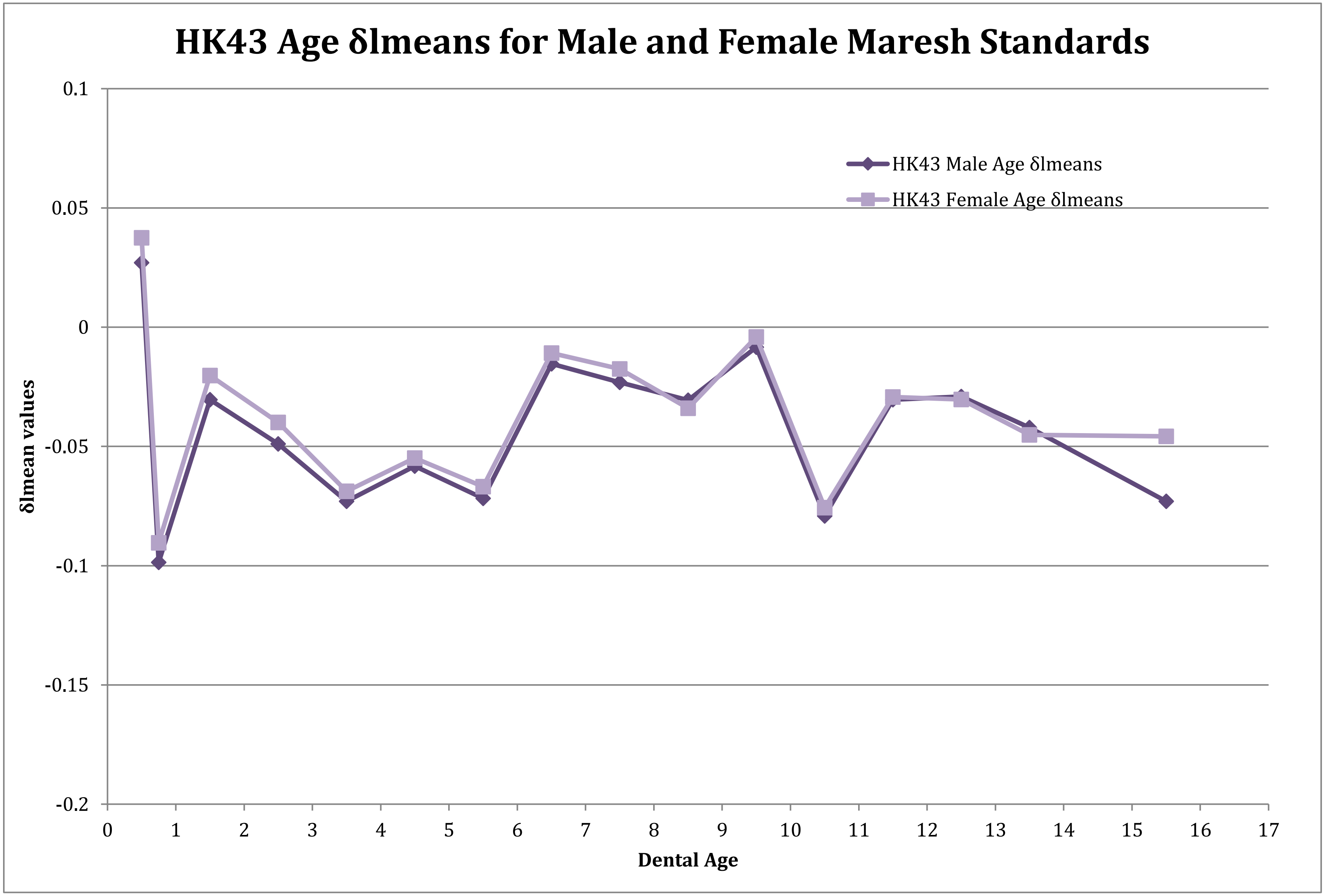


Figure 7: South Tombs Cemetery individual δlmean values and age δlmean values plotted for the female Maresh Standards.



Male and female age δlmean values were also calculated for each dental age for the HK43 cemetery growth sample and were graphed as a trend line on figures five and six. Unlike the male and female age δlmeans lines for the STC sample, the HK43 age δlmeans lines did exceed the line of unity at 7.5 months for both the male and female Maresh Standards. This suggests that the children with this dental age were meeting or exceeding the growth standard for their first few months. The age δlmean for 9.5 olds was very close to surpassing the line of unity in both males and females indicating good achieved growth for those individuals. This further supports that the STC growth sample had poorer achieved-growth than those from the HK43 cemetery growth sample even during early infancy and late childhood. The δlmean values for the other dental ages appear to fluctuate greatly around the -0.05 value. The greater fluctuation is possibly due to the smaller sample size of the HK43 cemetery. The male and female age δlmeans for the HK43 are plotted together in figure eight. Although the female age δlmeans tend to be slightly higher, there is no significant difference between the male and female age δlmeans (Independent sample t test, all p values > 0.05). Whether these individuals are considered male or female, they are consistently reaching similar achieved growth for their dental ages based on the Maresh Standards.

Figure 8: HK43 cemetery age δlmean values plotted for male and female Maresh Standards.



Tables five and six consist of the percentage of individuals from the HK43 cemetery growth sample that are above and below the line of unity for each dental age, as well as percentage of individuals with an individual δlmean values above and below -0.05. Table five are the values calculated using the male Maresh Standards, whereas table six are the values calculated using the female Maresh Standards. The only variation between the two individuals is the percentage of 9.5 year olds that are below or above the line of unity. In this skeletal sample, there is a far less consistent pattern from the values. Like the STC, the HK43 sample has good, if not great growth during the first 7.5 months, as all of the individuals in this age category exceeded the standard for the age. From 10.5 months to 5.5 years achieved-growth appears to decline, although not nearly as poorly as the STC sample. Like the STC sample, the number of individual's achieved-growth rises starting around 6.5 years. Unlike the STC, however, the HK43 sample continues on a trend of better achieved-growth throughout the late childhood and into young adulthood. Only four dental ages have male individual δlmean values that are majoritively less than 0.05: 10.5 month, 3.5 years, 5.5 years, and 10.5 years. There are only three female δlmean values that are less than 0.05: 10.5 months, 3.5 years, and 5.5 years. This is considerably less than the eleven and nine reported for the STC respectively. These dental ages, however, are consistent with the periods of decreased achieved growth identified in the STC data.

Table 5: Percentage of individuals from the HK43 cemetery growth sample above and below the line of unity, as well as less than and greater than -0.05 for the male Maresh Standard. The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (Line of Unity)	Greater than 0.0 (Line of Unity)
1.5 m	0				
4.5 m	0				
7.5 m	2	0%	100%	0%	100%
10.5 m	1	100%	0%	100%	0%
1.5 yrs	5	0%	100%	80%	20%
2.5 yrs	4	50%	50%	100%	0%
3.5 yrs	2	100%	0%	100%	0%
4.5 yrs	2	50%	50%	100%	0%
5.5 yrs	2	100%	0%	100%	0%
6.5 yrs	3	33%	67%	33%	67%
7.5 yrs	2	0%	100%	50%	50%
8.5 yrs	1	0%	100%	100%	0
9.5 yrs	2	0%	100%	100%	0
10.5 yrs	1	100%	0%	100%	0
11.5 yrs	3	33%	67%	67%	33%
12.5 yrs	1	0%	100%	100%	0%
13.5 yrs	1	0%	100%	100%	0%
14.5 yrs	0				
15.5 yrs	2	50%	50%	100%	0%
16.5 yrs	0				

Table 6: Percentage of individuals from the HK43 cemetery growth sample above and below the line of unity, as well as less than and greater than -0.05 for the female Maresh Standard The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (Line of Unity)	Greater than 0.0 (Line of Unity)
1.5 m	0				
4.5 m	0				
7.5 m	2	0%	100%	0%	100%
10.5 m	1	100%	0%	100%	0%
1.5 yrs	5	0%	100%	80%	20%
2.5 yrs	4	50%	50%	100%	0%
3.5 yrs	2	100%	0%	100%	0%
4.5 yrs	2	50%	50%	100%	0%
5.5 yrs	2	100%	0%	100%	0%
6.5 yrs	3	33%	67%	33%	67%
7.5 yrs	2	0%	100%	50%	50%
8.5 yrs	1	0%	100%	100%	0
9.5 yrs	2	0%	100%	50%	50%
10.5 yrs	1	100%	0%	100%	0
11.5 yrs	3	33%	67%	67%	33%
12.5 yrs	1	0%	100%	100%	0%
13.5 yrs	1	0%	100%	100%	0%
14.5 yrs	0				
15.5 yrs	2	50%	50%	100%	0%
16.5 yrs	0				

St. Martin's Churchyard (SMC)

Figures nine and 10 are scatter plots of individual δlmean values for the SMC sample. Figure nine calculated the individual δlmean values using the male Maresh Standards, whereas figure 10 used the female averages. The SMC only has two individuals that are above the line of unity for the male Maresh Standrads, which is less than 3% of the population. These two individuals met or exceeded the male Maresh standard for their age. These individuals were 1.5 and 8.5 years old. When using the female Maresh Standards rather than the males the number of individuals above the line of unity increases to six. These individual values were distributed across the following dental ages: 1.5 months, 4.5 months, 7.5 months, 1.5 years, 8.5 years, and 9.5 years. The age distribution of these individuals is similar to that seen at the HK43 and STC growth samples, except that the STC does not have the older late childhood individuals meeting the standard of growth. A large majority of the sample population is falling below the male and female Maresh Standards for dental age. The SMC individual δlmean values for male Maresh standards indicate that 97.8% of the subsample falls below the line of unity and that 56.5% of the subsample is below -0.05. Figure seven shows that 93.5% of the growth sample falls below the line of unity for the female Maresh standard and that 53.3% of the subsample were even poorer falling below -0.05. When compared to the STC and HK43 samples using the male Maresh Standard the SMC sample is not significantly different (Fisher's Exact Test, STC versus SMC p value = 0.8848, HK43 versus SMC p value = 0.0747). There is no significant differences when using the female Maresh Standard (Fisher's Exact Test, STC versus SMC p value = 0.3908, HK43 versus SMC p value = 0.1619). This implies that the majority of these skeletal samples were not meeting the expected growth standard for their dental ages.

Figure 9: St. Martin's Churchyard individual δlmean values and age δlmean values plotted for the male Maresh Standards.

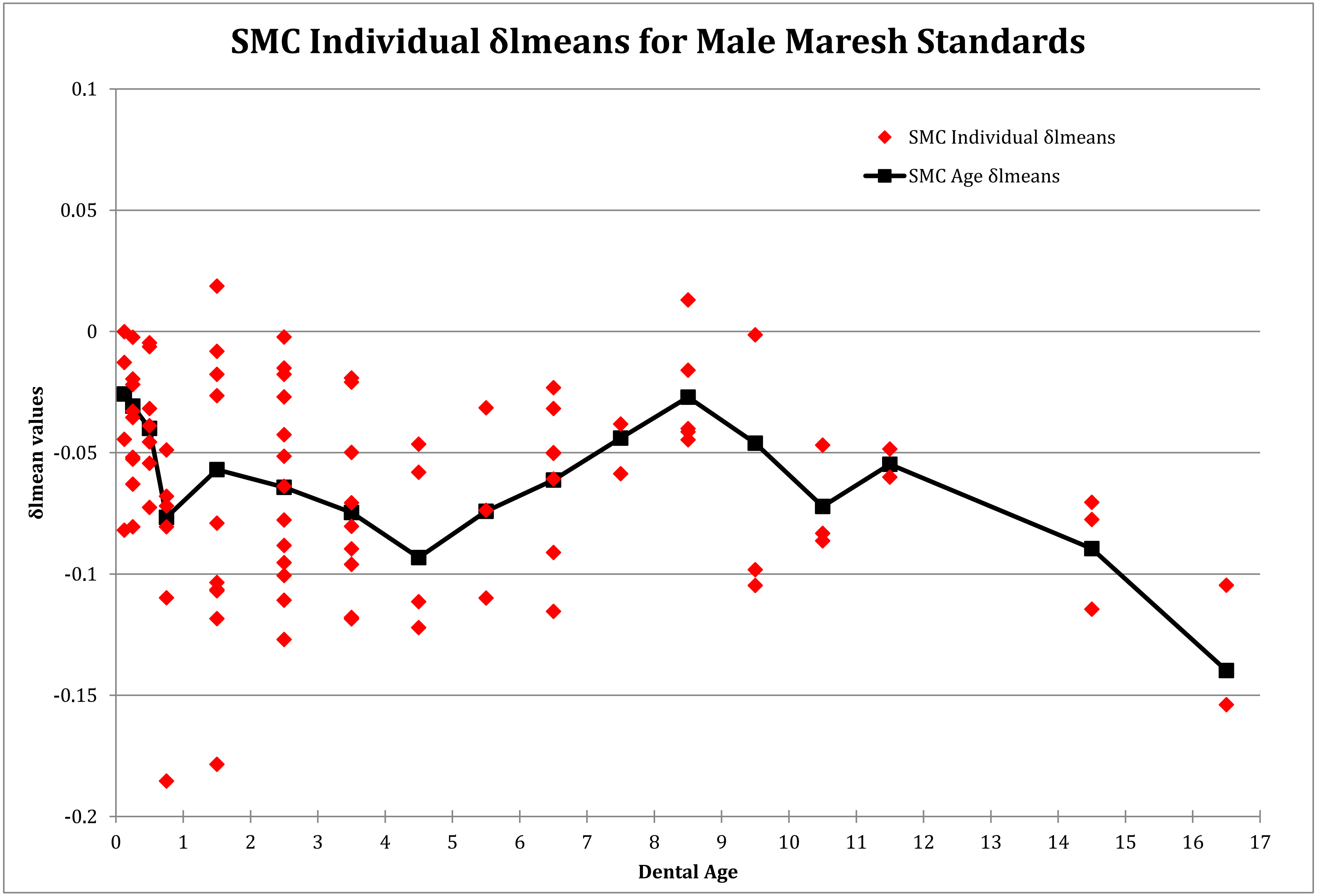
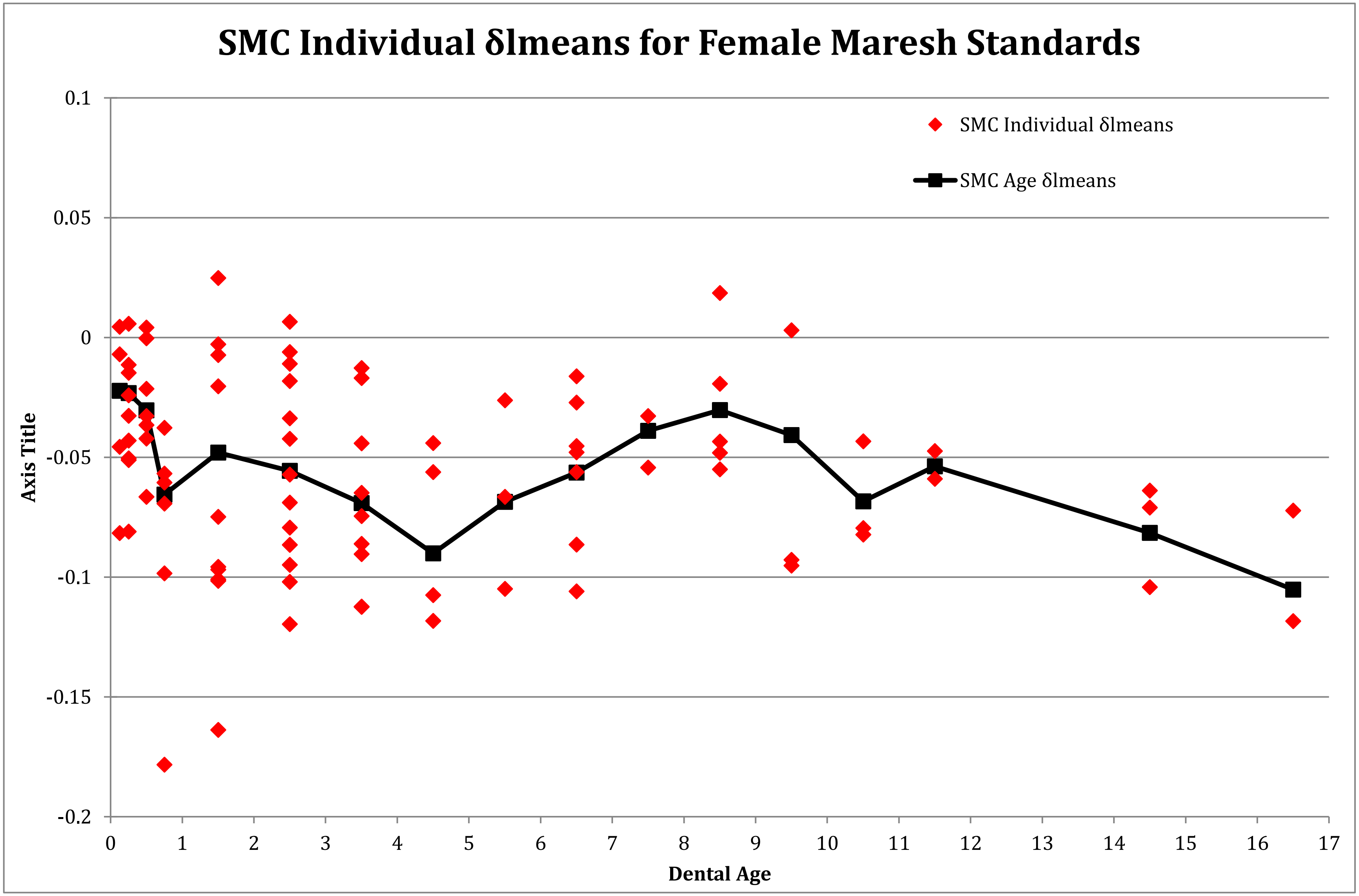
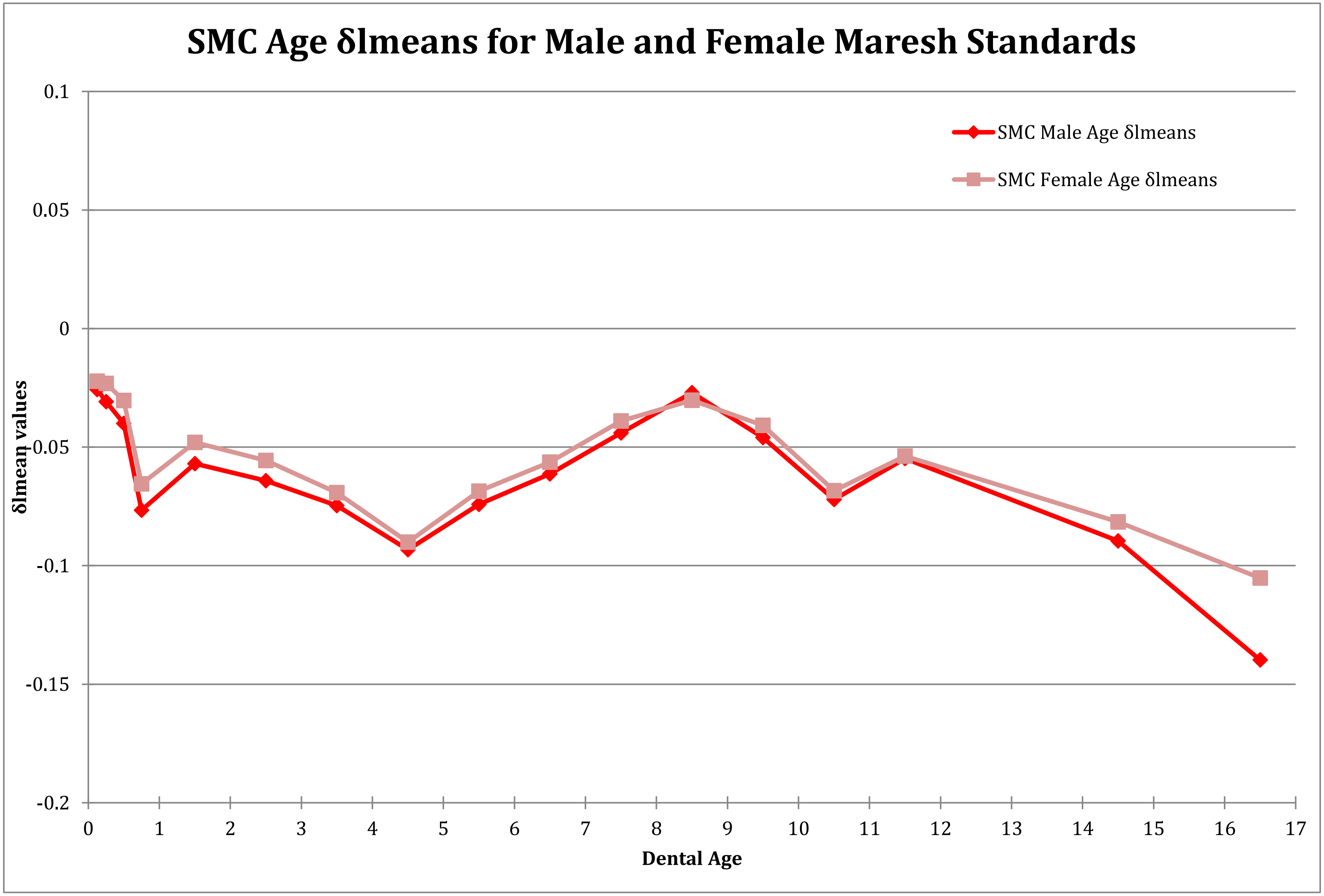


Figure 10: St. Martin's Churchyard individual δlmean values and age δlmean values plotted for the female Maresh Standards.



Male and female age δlmeans were computed for each dental age for the SMC growth sample and were graphed on figures nine and 10. Unlike the male and female age δlmeans for the STC and HK43, none of the male and female age δlmean values exceeded the line of unity for any of the dental ages. This suggests that the children from the SMC generally had poor achieved growth for all of the dental ages. This is not consistent with the δlmean values for the STC and HK43 samples that demonstrated good achieved growth among some of the dental ages in infancy and late childhood. The majority of the SMC age δlmean values concentrate around the -0.05 value. The male and female age δlmeans for the SMC sample are plotted together in figure 11. Although the female age δlmeans tend to be slightly higher, there is no significant difference between the male and female age δlmeans, except at the age of 16.5 years (Independent sample t test, p value = 0.0436). The male age δlmeans have a greater decline when compared to the female age δlmeans at the age of 14.5 years, which is consistent with the male and female comparison for the STC and HK43. Whether these individuals are considered male or female, they are consistently reaching similar poor achieved growth for their dental ages based on the Maresh Standards.

Figure 11: St. Martin's Churchyard age δlmean values plotted for male and female Maresh Standards.



Tables seven and eight consist of the percentage of individuals from the SMC growth sample that are above and below the line of unity for each dental age, as well as percentage of individuals with an individual δlmean values above and below -0.05. Table seven are the values calculated using the male Maresh Standards, whereas table eight are the values calculated using the female Maresh Standards. There was very little difference between the percentages for male and females shown in the two charts. The percentage of 6.5 year olds did result in slight changes that resulted in a higher percentage of individuals above -0.05 when the female Maresh Standard was used. However, this did not have a huge effect on the general pattern of the growth for the SMC sample. Similar to the STC and HK43 growth samples, SMC has the best achieved growth during the first 7.5 months of life. However, none of the values exceeded the line of unity for theses ages implying poorer achieved growth during infancy than the other samples. After 10.5 months, achieved-growth appears to decline. There is slight improvement at the ages of 6.5 year and 8.5 years but it is not like the STC and HK43 samples that saw a number of increases in ages of late childhood. SMC continues the trend of poor achieved-growth through the late childhood and into young adulthood. Eleven and 10 dental ages of the 17 represented in the sample are majoritively less than 0.05. This is more consistent with the STC reported percentages than with the HK43 values. These dental ages are consistent with the periods of decreased achieved growth identified in the STC data.

Table 7: Percentage of individuals from the St. Martin's Churchyard growth sample above and below the line of unity, as well as less than and greater than -0.05 for the male Maresh Standard The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (Line of Unity)	Greater than 0.0 (Line of Unity)
1.5 m	4	25%	75%	100%	0%
4.5 m	9	44%	56%	100%	0%
7.5 m	7	29%	71%	100%	0%
10.5 m	6	83%	17%	100%	0%
1.5 yrs	10	60%	40%	90%	10%
2.5 yrs	13	62%	38%	100%	0%
3.5 yrs	9	67%	33%	100%	0%
4.5 yrs	4	75%	25%	100%	0%
5.5 yrs	3	67%	33%	100%	0%
6.5 yrs	7	57%	43%	100%	0%
7.5 yrs	2	50%	50%	100%	0%
8.5 yrs	5	0%	100%	80%	20%
9.5 yrs	3	67%	33%	100%	0%
10.5 yrs	3	67%	33%	100%	0%
11.5 yrs	2	50%	50%	100%	0%
12.5 yrs	0				
13.5 yrs	0				
14.5 yrs	3	100%	0%	100%	0%
15.5 yrs	0				
16.5 yrs	2	100%	0%	100%	0%

Table 8: Percentage of individuals from the St. Martin's Churchyard growth sample above and below the line of unity, as well as less than and greater than -0.05 for the female Maresh Standard. The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (Line of Unity)	Greater than 0.0 (Line of Unity)
1.5 m	4	25%	75%	75%	25%
4.5 m	9	33%	67%	89%	11%
7.5 m	7	14%	86%	86%	14%
10.5 m	6	83%	17%	100%	0%
1.5 yrs	10	60%	40%	90%	10%
2.5 yrs	13	53%	47%	100%	0%
3.5 yrs	9	67%	33%	100%	0%
4.5 yrs	4	75%	25%	100%	0%
5.5 yrs	3	67%	33%	100%	0%
6.5 yrs	7	43%	57%	100%	0%
7.5 yrs	2	50%	50%	100%	0%
8.5 yrs	5	20%	80%	80%	20%
9.5 yrs	3	67%	33%	67%	33%
10.5 yrs	3	67%	33%	100%	0%
11.5 yrs	2	50%	50%	100%	0%
12.5 yrs	0				
13.5 yrs	0				
14.5 yrs	3	100%	0%	100%	0%
15.5 yrs	0				
16.5 yrs	2	100%	0%	100%	0%

Cedar Grove Cemetery (CGC)

Figures 12 and 13 are scatter plots of individual δlmean values for the CGC sample. Figure 12 calculated the individual δlmean values using the male Maresh Standards, whereas figure 13 used the female averages. The CGC growth sample has 10 individuals that are above the line of unity for the male Maresh Standrads, which translates to 35.7% of its population being at, or above the line of unity at the time of their death. These 10 individuals were meeting, or had exceeded the growth standard for their age based on the male Maresh Standard. These individual values were distributed across the following dental ages: 1.5 months, 10.5 months, 1.5 years, 6.5 years, 7.5 years, 8.5 years, and 9.5 years. The age distribution of these individuals is similar to that seen at the STC and HK43 samples that has late children that are meeting the standard of growth for their dental age suggesting better achieved-growth among the older subadults in this skeletal population. When using the female Maresh Standards rather than the males the number of individuals above the line of unity increases to 12, which is 42.9% of the population. The two additional individuals have a dental age of 10.5 months and 1.5 years. A larger portion of the sample population is falling above the male and female Maresh Standards than any other sample. The CGC individual δlmean values for male Maresh standards indicate that 64.3% of the subsample falls below the line of unity and that 21.4% of the subsample is below -0.05. Figure 13 shows that 57.1% of the growth sample falls below the line of unity for the female Maresh standard and that 21.4% of the subsample were below -0.05. When compared to the STC and SMC samples using the male and female Maresh Standards the CGC sample is significantly different (Fisher's Exact Test, p value > 0.05). There is no significant differences between HK43 and CGC growth samples (Fisher's Exact Test, p value = 0.1774). This implies that the CGC had significantly better achieved growth than the STC and SMC samples.

Figure 12: Cedar Grove Cemetery individual δlmean values and age δlmean values plotted for the male Maresh Standards.

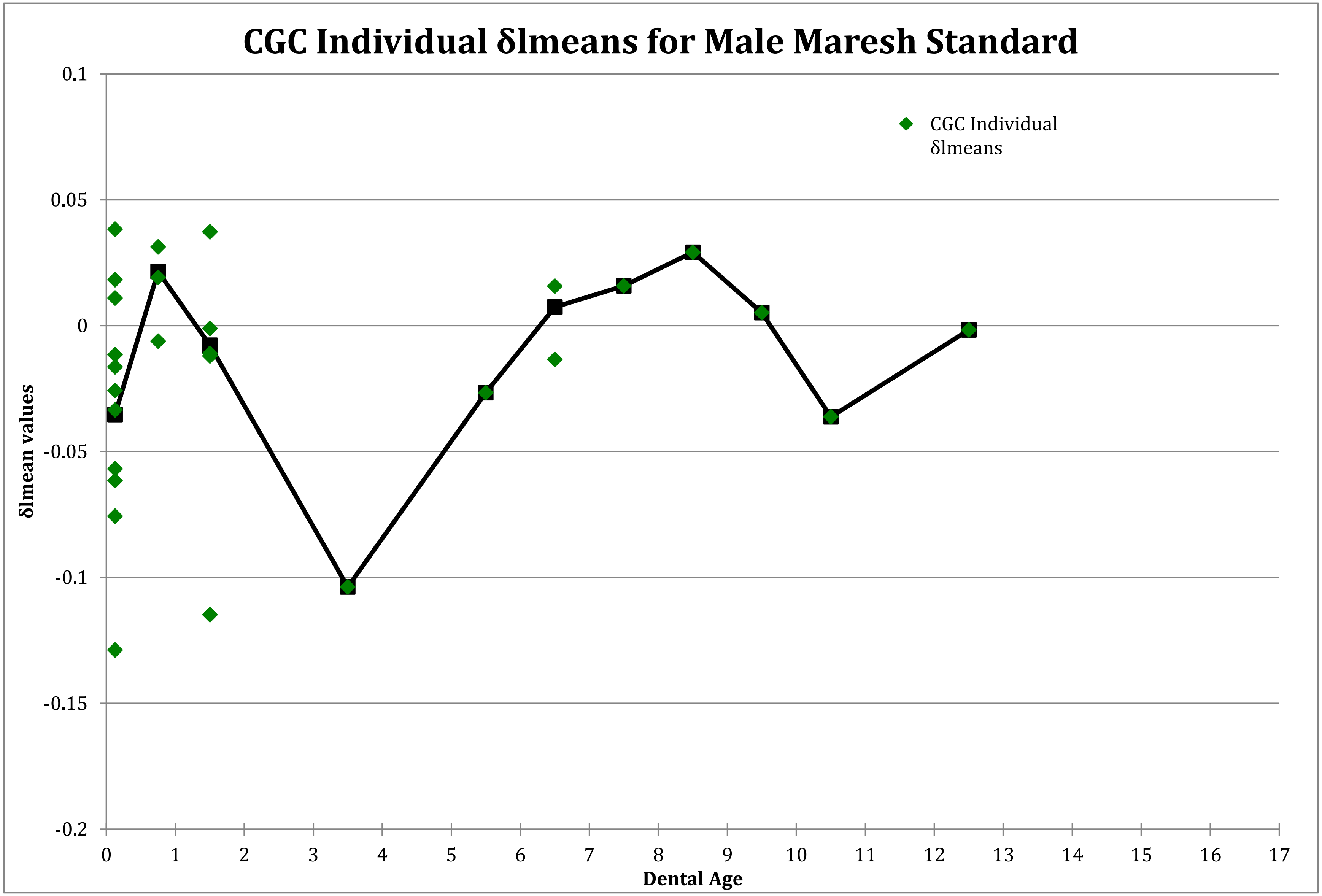
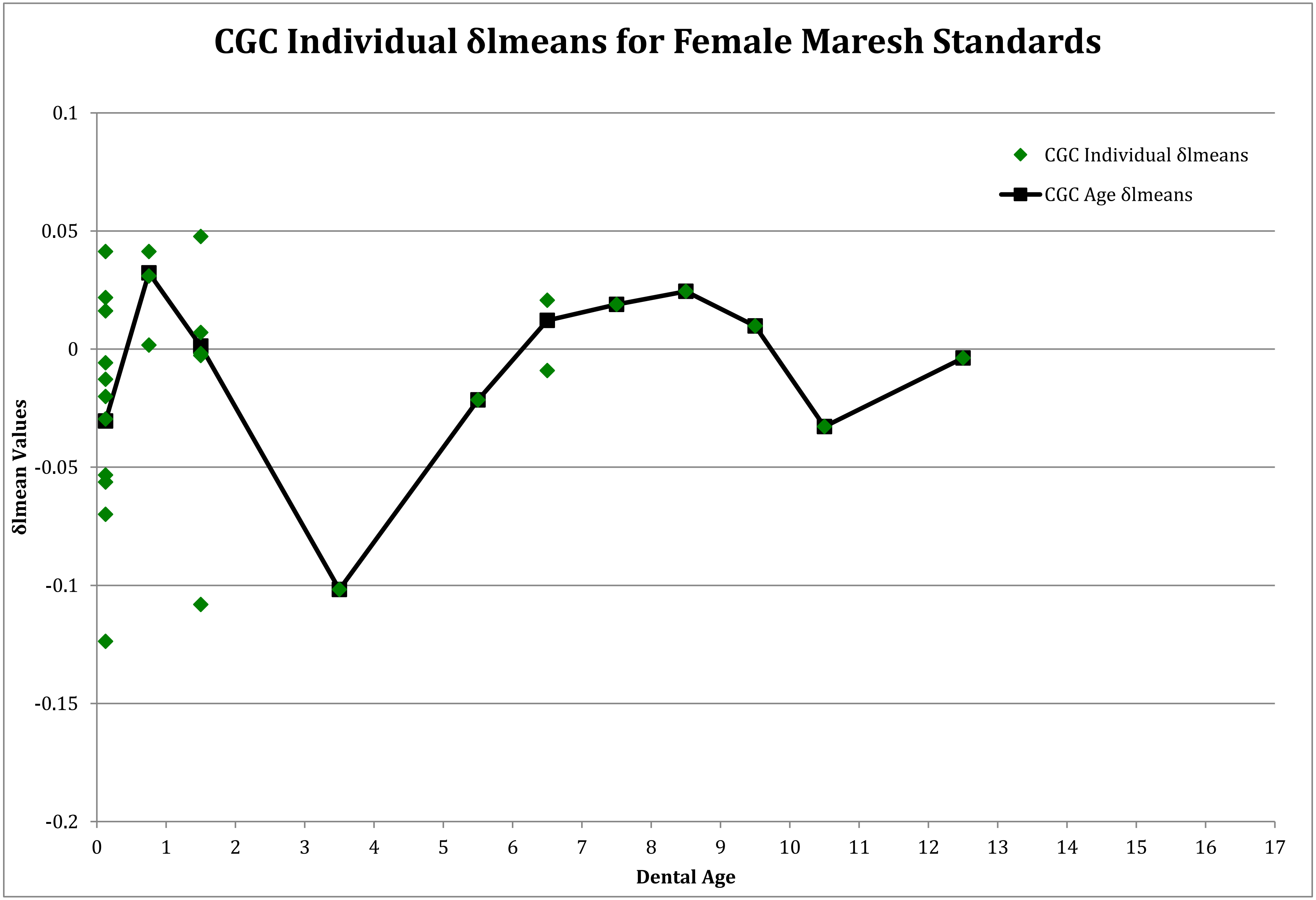
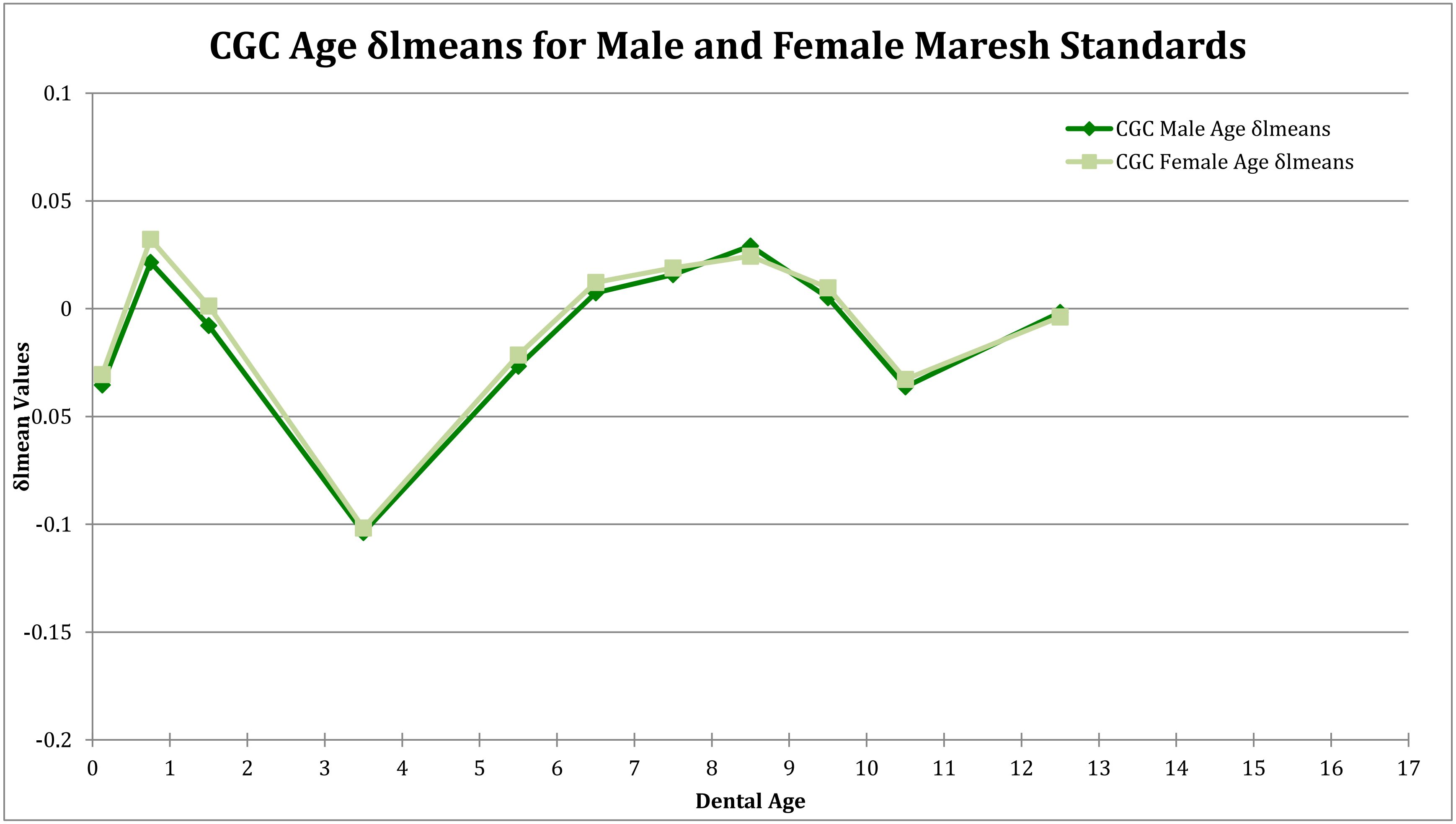


Figure 13: Cedar Grove Cemetery individual δlmean values and age δlmean values plotted for the female Maresh Standards



CGC male and female age δlmean values were also calculated for each dental age and were graphed in a line on figures 12 and 13. Five of the male and six of the female age δlmeans are above the line of unity for the 11 dental ages represented in this sample. This is expected for the CGC due to the high number of individuals that are above the line of unity and further demonstrates the better achieved growth for this population. Only one falls below the value -0.05. The 3.5-year-old age δlmean considerably different from the other age δlmeans, which may be because only one 3.5 year old was included in the CGC sample. The rest of the age δlmeans appear to center on the line of unity rather than -0.05 like the other samples. The male and female age δlmeans for the STC are plotted together in figure 14. There is no significant difference between the male and female age δlmeans (Independent samples t test, all p values > 0.05). It is important to note that the CGC sample has no individuals older than 12.5 years of age. The male and female difference reported in the other samples occurred at 16.5 years. Due to the lack of young adults in the CGC growth sample, any significant difference between the male and female age δlmeans for the young adults in undeterminable.

Figure 14: Cedar Grove Cemetery age δlmean values plotted for Male and Female Maresh Standards.



Tables nine and ten contain the percentage of individuals from the SMC growth sample that are above and below the line of unity for each dental age, as well as percentage of individuals with an individual δlmean values above and below -0.05. Table nine are the values computed using the male Maresh Standards, whereas table eight are the values calculated using the female Maresh Standards. The only differences between the two charts are the percentages for the dental ages 10.5 months and 1.5 years. In both of these cases, the percentage of individuals with a δlmean value greater than the line of unity increased. However, this did not have a huge effect on the general pattern of the growth for the CGC sample. Generally, the CGC has better achieved growth than the other growth samples. However, the pattern of growth is very similar to the STC, SMC, and HK43 growth samples. CGC also starts with good achieved growth during the first year of life with the age values exceeding the line of unity at 7.5 months and 10.5 months of life indicating better achieved growth during infancy than the other samples. At 3.5 years achieved growth declines rapidly. As previously mentioned this may be due to the small sample size, as one individual is represented in this dental age. Subadults reaching the dental age of 5.5 years to 12.5 years show a better achieved-growth than the younger counterpart does. Achieved-growth during the later years and into young adulthood (13.5 years to 16.5 years) was not able to be examined due to these ages missing from the growth sample. The dental ages that showed higher values of achieved growth are consistent with the periods identified in the STC and other comparative data.

Table 9: Percentage of individuals from the Cedar Grove Cemetery growth sample above and below the line of unity, as well as less than and greater than -0.05 for the male Maresh Standard. The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (Line of Unity)	Greater than 0.0 (Line of Unity)
1.5 m	11	36%	64%	73%	27%
4.5 m	0				
7.5 m	3	0%	100%	33%	67%
10.5 m	0				
1.5 yrs	5	20%	80%	80%	20%
2.5 yrs	0				
3.5 yrs	1	100%	0%	100%	0%
4.5 yrs	0				
5.5 yrs	1	0%	100%	100%	0%
6.5 yrs	2	0%	100%	50%	50%
7.5 yrs	1	0%	100%	0%	100%
8.5 yrs	1	0%	100%	0%	100%
9.5 yrs	1	0%	100%	0%	100%
10.5 yrs	1	0%	100%	100%	0%
11.5 yrs	0				
12.5 yrs	1	0%	100%	100%	0%
13.5 yrs	0				
14.5 yrs	0				
15.5 yrs	0				
16.5 yrs	0				

Table 10: Percentage of individuals from the Cedar Grove Cemetery growth sample above and below the line of unity, as well as less than and greater than -0.05 for the female Maresh Standard. The highest percentages are shaded.

Dental Age	N	Less than -0.05	Greater than -0.05	Less than 0.0 (Line of Unity)	Greater than 0.0 (Line of Unity)
1.5 m	11	36%	64%	73%	27%
4.5 m	0				
7.5 m	3	0%	100%	0%	100%
10.5 m	0				
1.5 yrs	5	40%	60%	60%	40%
2.5 yrs	0				
3.5 yrs	1	100%	0%	100%	0%
4.5 yrs	0				
5.5 yrs	1	0%	100%	100%	0%
6.5 yrs	2	0%	100%	50%	50%
7.5 yrs	1	0%	100%	0%	100%
8.5 yrs	1	0%	100%	0%	100%
9.5 yrs	1	0%	100%	0%	100%
10.5 yrs	1	0%	100%	100%	0%
11.5 yrs	0				
12.5 yrs	1	0%	100%	100%	0%
13.5 yrs	0				
14.5 yrs	0				
15.5 yrs	0				
16.5 yrs	0				

Comparison of Growth

Figures 15 and 16 are graphs of the male and female age δlmean values for the STC, HK43, SMC, and CGC growth samples. Independent sample t tests were conducted for comparison of means between each of the mortuary samples, and the p values for each age comparison are listed in tables 11 and 12. Cedar grove's age δlmeans were significantly different from the majority of the other samples' values. This is consist with the fact that CGC had the highest δlmean values for nine of its eleven ages represented in the mortuary sample. All of the male and female means for SMC and CGC were significantly different (p values < 0.05), except for the 1.5 month age. The SMC and CGC were the only samples with subadults representing this age, and both show significantly comparable poor achieved growth at this age. The 10.5 age δlmeans were significantly different between STC and CGC only when the male Maresh standards were used. This is the only time that the male and female Maresh standards differed in their statistical results. However, both p values are very close in value to the 0.05 significance level, and the fluctuation may be due to the small sample size of this age. HK43 had the most number of age δlmeans that were not significantly different from the CGC's values, which suggests that at the ages of 6.5, 9.5, and 12.5 these samples had similar achieved growth. Despite the smaller sample size, HK43 consistently has greater age δlmeans for each dental age than the STC growth sample. HK43 has greater age δlmeans for 11 of the 16 corresponding dental ages than STC. Eight of the 16 age δlmean values for the STC and HK43 mortuary samples are significantly different (p values < 0.05). These ages include 7.5 months, 10.5 months, 1.5 years, 2.5 years, 6.5 years, 9.5 years, 10.5 years, and 11.5 years. All of which coincide with distinct social age groups and transition periods identified in chapter three. STC has significantly lower age δlmeans in six of these eight ages suggest poorer achieved growth than HK43. The STC showed slightly less difference in age δlmeans when compared to the SMC sample. The SMC has the lowest age δlmeans values of all the mortuary samples. Of the 17 ages represented in the SMC sample only the 1.5 months age δlmean value was the highest, but was not significantly different when compared to the only other mortuary sample with this age group (p value > 0.05). The STC and SMC had seven age δlmeans that were significantly different (p value < 0.05). These included 4.5 months, 7.5 months, 2.5 years, 4.5 years, 6.5 years, 10.5 years, and 11.5 years. The SMC sample had a lower age δlmean for five of the seven that were significantly different. The STC had lower age δlmeans at 2.5 years and 11.5 years. When the SMC and HK43 subadult samples were compared there were six of the thirteen ages that had significantly different age δlmeans values. These included 7.5 months, 10.5 months, 1.5 years, 6.5 years, 9.5 years, and 11.5 years. The SMC was had significantly lower age δlmeans for all of these ages than HK43. Based on the comparison of age δlmeans the subadult samples can be ranked based on their general pattern of growth. The CGC is considered to have the best subadult achieved growth among the mortuary samples. HK43 would be next, followed by STC. The SMC subadult sample has the worse overall achieved growth for all of the samples compared in this investigation.

Figure 15: Male age δlmean values plotted for the South Tombs Cemetery, HK43 cemetery, St. Martin's Churchyard, and the Cedar Grove Cemetery.

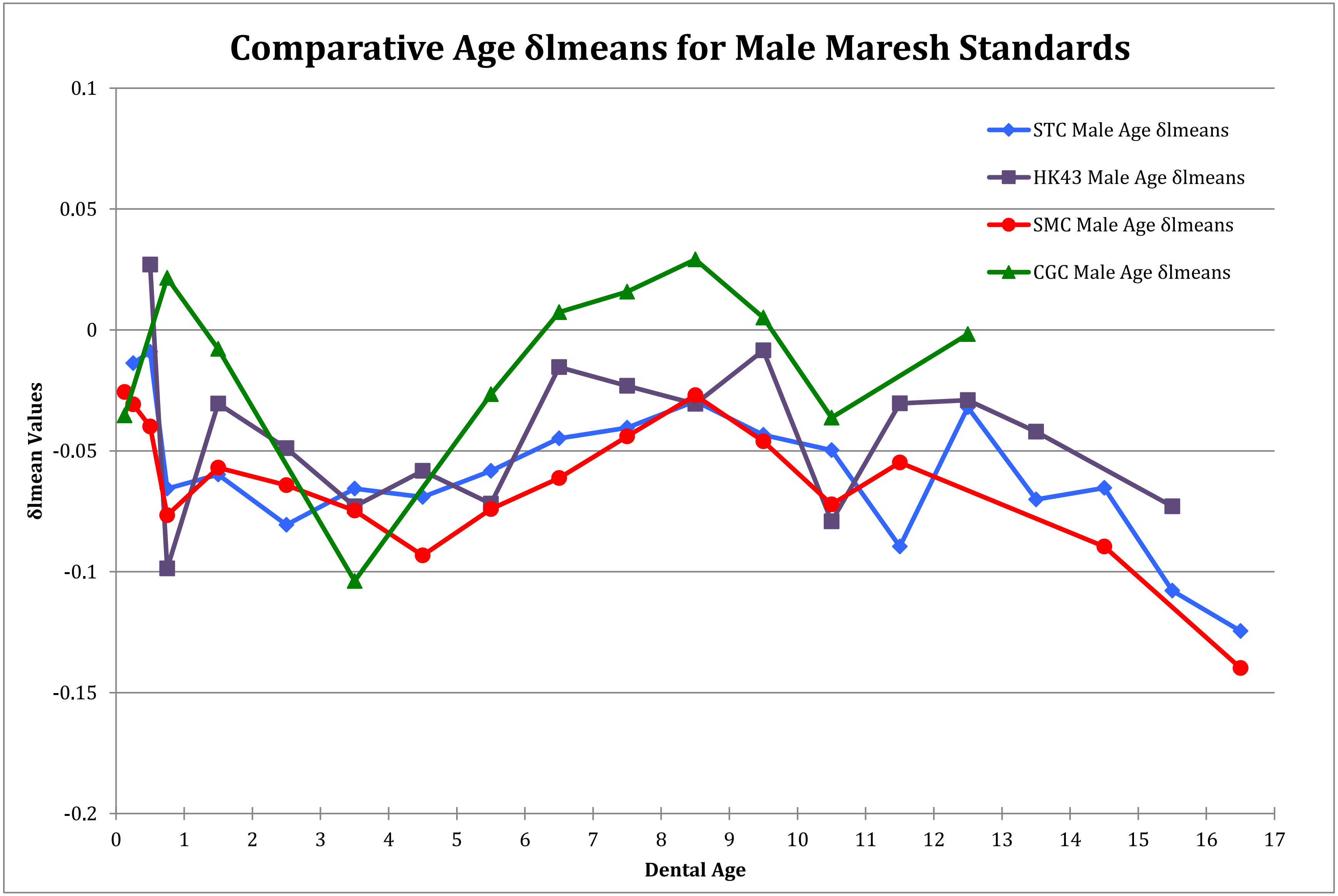


Figure 16: Female age δlmean values plotted for the South Tombs Cemetery, HK43 cemetery, St. Martin's Churchyard, and the Cedar Grove Cemetery

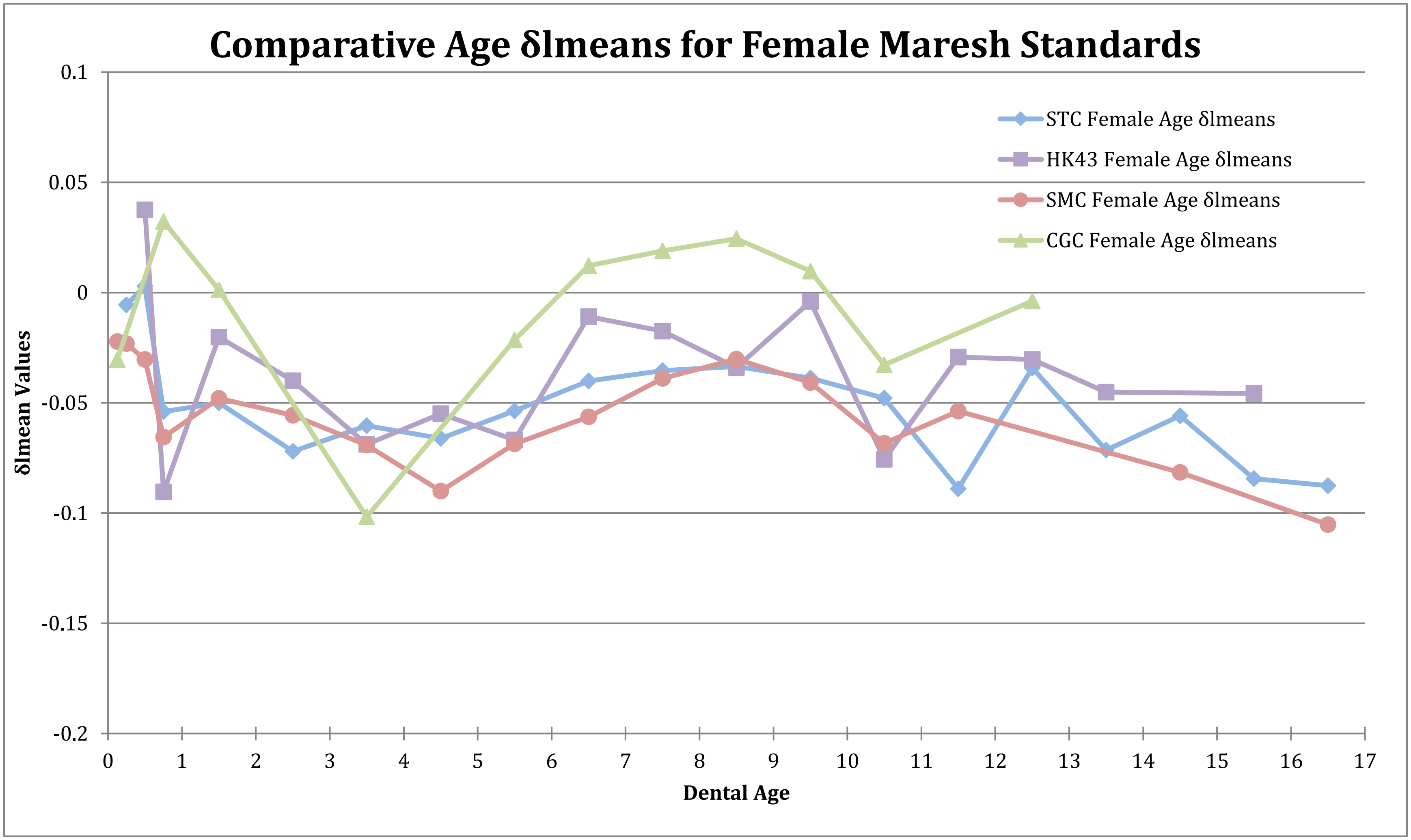


Table 11: The p values are listed from the independent samples t tests for the comparison of the male age δlmeans. The highlighted square indicate the p values that were significant at 0.05.

Age	STC vs HK43 p values	STC vs SMC p values	STC vs CGC p values	HK43 vs SMC p values	HK43 vs CGC p values	SMC vs CGC p values
1.5 months						0.3859
4.5 month		0.0443				
7.5 months	0.0060	0.0002	0.0000	0.0001		
10.5 months	0.0001	0.1086	0.0000	0.0024	0.0000	0.0000
1.5 years	0.0001	0.8288	0.0000	0.0384	0.0315	0.0018
2.5 years	0.0009	0.0203		0.0979		
3.5	0.2446	0.1498		0.8418		
4.5	0.5500	0.0301		0.0767		
5.5	0.1123	0.2781	0.0002	0.8375	0.0000	0.0007
6.5	0.0211	0.0411	0.0000	0.0008	0.0791	0.0000
7.5	0.1468	0.6405	0.0002	0.1208	0.0110	0.0001
8.5	0.8335	0.6768	0.0000	0.5723	0.0000	0.0000
9.5	0.0012	0.8794	0.0000	0.0448	0.1317	0.0093
10.5	0.0035	0.0010	0.0585	0.3322	0.0000	0.0003
11.5	0.0000	0.0006		0.0183		
12.5	0.8034		0.0005		0.0663	
13.5	0.3096					
14.5		0.1106				
15.5	0.3739					
16.5		0.2120				

Table 12: The p values are listed from the independent samples t tests for the comparison of the female age δlmeans. The highlighted square indicate the p values that were significant at 0.05.

Age	STC vs HK43 p values	STC vs SMC p values	STC vs CGC p values	HK43 vs SMC p values	HK43 vs CGC p values	SMC vs CGC p values
1.5 months						0.4780
4.5 month		0.0332				
7.5 months	0.0120	0.0001		0.0001		
10.5 months	0.0000	0.1026	0.0000	0.0007	0.0000	0.0000
1.5 years	0.0002	0.8815	0.0001	0.0271	0.0473	0.0015
2.5 years	0.0011	0.0224		0.0978		
3.5	0.2017	0.1586		0.9703		
4.5	0.5446	0.0298		0.0797		
5.5	0.1348	0.3044	0.0005	0.8783	0.0001	0.0008
6.5	0.0224	0.0403	0.0001	0.0008	0.0862	0.0000
7.5	0.1396	0.6366	0.0001	0.1225	0.0188	0.0001
8.5	0.9548	0.7070	0.0055	0.7027	0.0067	0.0084
9.5	0.0027	0.9066	0.0000	0.0492	0.1418	0.0084
10.5	0.0026	0.0126	0.0452	0.3272	0.0002	0.0003
11.5	0.0000	0.0007		0.0197		
12.5	0.7596		0.0002		0.0827	
13.5	0.2793					
14.5		0.0802				
15.5	0.3116					
16.5		0.1555				

Individual Skeletal Elements

Sciulli (1994) suggested that long bones with the most rapid growth would be affected more by environmental stress. Sciulli's (1994) data on five Native American populations and the New York African Burial Ground data reported by Goode-Null (2002) showed that the lower limb tends to have the lowest δl values when compared with the upper limb. Sciulli (1994) found that Native Americans had a consistent, significant sequence from the most effected long bones to the least effected (p value < 0.005). The sequence is femur, fibula, tibia, humerus, ulna, and radius. According to Sciulli (1994), the cause of these variations between skeletal elements are due to the difference in growth rate. Rapidly growing long bones are affected more by nutritional and disease stress. Tables 13 and 14 shows the male and female long bone δlmean values for all subadult samples. Sciulli's sequence is not seen in the subadult samples used in this growth study. The STC is the most similar to those reported by Sciulli (1994) with the lower limb being affected more than the upper limb. However, the fibula is affected as much, if not more than the femur, and the radius is affected more than the ulna for both Maresh standards. In HK43, the humerus is affected more than the tibia for both standards, which is not consistant with the generalization of the lower limb being impacted more than the upper limb. The male Maresh standards resulted in the radius being affected more than the ulna in the HK43 sample. There is no apparent sequence in the SMC sample whether the male or the female standard is used. The standards give two very different sequences with the only similarity being that the humerus is the most affected bone. The CGC also differs from Scuilli's sequence in the fact that the tibia is the most affected long bone. These results suggest that Scuilli's finding may be unique to his Native American samples and may not be a universal phenomenon or is more complicated than previously thought. Scuilli also does not state in his article whether he used the male or female Maresh values, but this study shows that the standard being used does affect the impact sequence for long bones. The mortuary samples in this study showed difference in sequence depending on the Maresh values, male or female, used in creating the ratio means.

Table 13: Long bone male δlmean values for subadult samples.

	Humerus δlmean	**Ulna δlmean**	**Radius δlmean**	**Femur δlmean**	**Tibia δlmean**	**Fibula δlmean**
STC	-0.052	-0.041	-0.048	-0.060	-0.053	-0.062
HK43	-0.047	-0.028	-0.029	-0.048	-0.028	-0.048
SMC	-0.046	-0.068	-0.068	-0.059	-0.062	-0.066
CGC	-0.010	-0.010	-0.019	-0.029	0.002	-0.022

Table 14: Long bone female δlmean values for subadult samples.

	Humerus δlmean	**Ulna δlmean**	**Radius δlmean**	**Femur δlmean**	**Tibia δlmean**	**Fibula δlmean**
STC	-0.049	-0.032	-0.035	-0.057	-0.051	-0.057
HK43	-0.043	-0.020	-0.016	-0.046	-0.026	-0.044
SMC	-0.041	-0.058	-0.054	-0.056	-0.060	-0.060
CGC	-0.006	-0.001	-0.004	-0.030	0.000	-0.015

When the Egyptian samples are compared, the STC consistently has lower δ1mean values for each long bone than HK43. The radius and tibia δlmeans are significantly different between the two cemeteries (p values <0.05). This indicates that achieved growth for these long bones is poorer in the STC sample population than in the HK43 sample. These bones, unlike the femur are slower growing bones and their growth rate is uniform throughout childhood and adolescence

(Scheuer and Black 2000). The femur has a faster growth rate that changes when the individual reaches puberty, where upon it undergoes a period of rapid growth. This means that the STC subadult sample experienced poor achieved growth not only in the faster growing bones but also in the slower growing bones suggesting long intervals of poor growth.

When the SMC is compared to the other subadult samples, the SMC has lowest δ1means for all of long bones, except for the humerus and femur values of the STC. The long bone δ1mean values are statistically different for the ulna and radius of the SMC and STC samples (p value < 0.05). This suggests that the SMC has significantly poorer achieved growth in the bones of the forearm, but similar achieved growth with the STC subadults in the lower limbs.

The CGC long bone δ1means are all significantly different from the other subadult samples (p value < 0.05). This suggests that the CGC had the best achieved growth of all of the mortuary samples compared in this investigation. CGC was also the only sample that met, or exceed the Maresh Standards of growth for one or more long bone δ1means. The tibia male and female δ1means were the highest values of any of the samples compared.

In tables 15 through 22, δlimean values are listed for each long bone in each age group based on male and female, as well as age group δ1means calculated for all long bone δ1means for a given age category. The lowest δ1means are highlighted to identify the period of poorest achieved growth for each mortuary sample. For the STC the lowest values are all in the toddler age group (dental age: 1.5 year to 2.5 years) for both the male and female standards. The toddler age group δ1means are significantly different from the other age groups represented in the STC subadult sample (p value < 0.01). δ1means values are the lowest in early childhood (dental age: 3.5 years to 6.5 years) for the HK43 mortuary sample. The early childhood scores are significantly different from the other age groups δ1means (p value <0.01). SMC had the lowest δ1means in the early childhood category, except for the ulna measurements that had the lowest values in the toddler stage. Despite the ulna δ1mean values being lower in the toddler group, the early childhood stage overall had the lowest age group δ1means. The early childhood δ1means were significantly different from the other age groups in the SMC sample (p value < 0.01). The CGC's lowest values were all in the infant age group (dental age: birth to 10.5 months). The infant age group δ1means were significantly different from the other CGC age groups (p value < 0.01).

The age group δ1means were then compared between the mortuary samples. The SMC had the lowest age group δ1means for all of the age stages, except for the toddler stage. The lowest toddler age δ1mean is the STC sample's value, which is significantly different from the other toddler age group δ1means (p value < 0.01). When the STC and HK43 samples are compared the age group δ1means are significantly different in all except for the early childhood category. The greatest difference in age group δ1means between the HK43 and STC samples were the toddler values. The CGC sample had the highest values for the age groups, except for the infant δ1means.

Table 15: Male long bone δlimean calculated based on age group for STC.

STC Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.022	-0.028	-0.038	-0.031	-0.010	-0.020	-0.025
Toddler	-0.070	-0.062	-0.061	-0.083	-0.070	-0.084	-0.072
Early Child	-0.055	-0.048	-0.054	-0.058	-0.055	-0.066	-0.056
Late Child	-0.051	-0.025	-0.040	-0.056	-0.060	-0.055	-0.049

Table 16: Female long bone δlimean calculated based on age group for STC.

STC Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.015	-0.009	-0.018	-0.027	-0.001	-0.010	-0.013
Toddler	-0.063	-0.049	-0.043	-0.079	-0.063	-0.075	-0.063
Early Child	-0.052	-0.041	-0.042	-0.056	-0.052	-0.062	-0.051
Late Child	-0.052	-0.022	-0.033	-0.054	-0.065	-0.052	-0.048

Table 17: Male long bone δlimean calculated based on age group for HK43.

HK43 Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.021	0.029	0.026	0.007	0.057	-0.101	0.002
Toddler	-0.046	-0.035	-0.030	-0.045	-0.034	-0.042	-0.039
Early Child	-0.069	-0.043	-0.040	-0.063	-0.041	-0.051	-0.051
Late Child	-0.042	-0.015	-0.027	-0.050	-0.029	-0.039	-0.033

Table 18: Female long bone δlimean calculated based on age group for HK43.

HK43 Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.013	0.048	0.046	0.011	0.067	-0.092	0.012
Toddler	-0.039	-0.022	-0.012	-0.040	-0.027	-0.034	-0.029
Early Child	-0.066	-0.037	-0.028	-0.062	-0.038	-0.047	-0.047
Late Child	-0.042	-0.012	-0.020	-0.050	-0.035	-0.037	-0.032

Table 19: Male long bone δlimean calculated based on age group for SMC.

SMC Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.039	-0.044	-0.053	-0.052	-0.046	-0.034	-0.045
Toddler	-0.050	-0.087	-0.065	-0.058	-0.051	-0.073	-0.062
Early Child	-0.050	-0.079	-0.084	-0.072	-0.082	-0.086	-0.074
Late Child	-0.038	-0.048	-0.058	-0.047	-0.062	-0.058	-0.051

Table 20: Female long bone δlimean calculated based on age group for SMC.

SMC Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.033	-0.028	-0.035	-0.050	-0.040	-0.025	-0.037
Toddler	-0.043	-0.075	-0.048	-0.054	-0.044	-0.065	-0.054
Early Child	-0.047	-0.072	-0.072	-0.071	-0.078	-0.082	-0.069
Late Child	-0.036	-0.043	-0.048	-0.043	-0.075	-0.053	-0.049

Table 21: Male long bone δlimean calculated based on age group for CGC.

CGC Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.020	-0.027	-0.034	-0.035	-0.009	-0.015	-0.024
Toddler	0.010	0.003	0.014	-0.024	0.004	-0.069	-0.008
Early Child	-0.004	-0.005	0.000	-0.039	-0.004		-0.014
Late Child	0.003	0.020	-0.001	-0.009	0.007	0.010	0.003

Table 22: Female long bone δlimean calculated based on age group for CGC.

CGC Age Groups	Humer δlimean	Ulna δlimean	Radius δlimean	Femur δlimean	Tibia δlimean	Fibula δlimean	Age Group δlimean
Infant	-0.016	-0.015	-0.019	-0.039	-0.005	-0.006	-0.018
Toddler	0.016	0.018	0.033	-0.020	0.012	-0.060	0.001
Early Child	-0.001	0.003	0.012	-0.038	-0.001		-0.010
Late Child	0.005	0.026	0.009	-0.008	-0.001	0.012	0.004

Conclusion

This chapter has discussed the results of the subadult growth analysis. The analysis focused on long bone growth of the major long bones and examined the cross sectional growth data from the four comparative samples. The samples were then ranked from best to poorest based on overall achieved growth using the δ1mean values: CGC, HK43, STC, and SMC. There was significant difference between the achieved growth reported in the Egyptian samples (p values < 0.05), and the STC had poorer achieved growth than HK43 in all of the age groups. The STC showed significantly poorer growth in the toddler stage than any other stage represented in the sample, which will be discussed further in chapter VIII. This chapter also showed that the difference between the male and female Maresh standards did not significantly affect the δ1mean values and results of the growth study (p value > 0.05). This examination has provided a general indicator of the health status of the subadults in the comparative mortuary samples. The next step in this research investigation is to examine indicators of stress found in the subadults skeletal samples.

Chapter VII.

Childhood Stress Assessment

The growth rate is biologically linked to the nutritional and infectious status of an individual (Goodman 1993). There is a constant trade-off of energy between the need to grow, survive, and reproduce (Paine and Hawkes 2006). Energy normally allocated for growth will be reallocated in an attempt to achieve or maintain a state of homeostasis when presented with biological stressors. Growth rate has been shown to slow or stop during periods of extreme nutritional and infectious stress (Tanner 1981). The length of the growth disruption will be dependent on the severity of the stress event and the individual's ability to respond appropriately to the stressor (Eveleth and Tanner 1990). The severity and degree of the growth disruption can also be dependent on the age of the individual and the timing of the event (Tanner 1981). Growth can be affected by many factors, such as nutrition, infection, migration, physical activity, physiological stresses, and environmental pressures (Bogin 1991; Brickley and Ives 2008; Cameron and Bogin 2013; Eveleth and Tanner 1990; Lewis 2007). The previous chapter has shown evidence of growth delays in many of the individuals from the STC and comparative samples, yet to fully understand the situations in which this growth disruptions took place the health and nutrition status of the subadults needs to be investigated. The incidences of non-specific skeletal stress markers (cribra orbitalia, porotic hyperostosis, linear enamel hypoplasias) and diseases of malnutrition (scurvy and rickets) are examined and compared in this chapter in order to provide insight into the subadult health and wellbeing of the STC, HK43, SMC and CGC skeletal populations.

Cribra Orbitalia and Porotic Hyperostosis

Cribra orbitalia is the occurrence of lesions in the eye sockets caused by the thinning and/or destruction of the outer table of the orbital vault, whereas porotic hyperostosis is used to refer to similar lesions that occur on the ectocranial surface of the cranial vault, usually centered on the parietal bones (White et al. 2012). Both cribra orbitalia and porotic hyperostosis lesions are identifiable in subadults with the expansion of the diploe bone appearing macroscopically as porosity, or pitting along the roof of the eye orbit or cranial vault. These lesions can occur bilaterally, or unilaterally and the severity can differ between the two sides. Although these lesions can co-occur in the same individual, the occurrence of one is not synonymous with the occurrence of the other. It has been theorized that the location of the pitting may be an indication of the stage, or time since the onset of the anemia and/or the severity of the anemia itself (Dickel 1991). The location of the lesion might also represent different etiologies and may suggest that these two lesions are the reaction to different stressors.

The etiology of these lesions is unclear, which is why it is considered a non-specific stress indicator often associated with the body’s need to increase erythrocyte production in response to anemia. It was originally suggested that cribra orbitalia and porotic hyperostosis were caused by iron-deficiency anemia based on the high prevalence of these lesions among the Maize dependent, Southwest Native American populations (el Najjar et al. 1975). The first to challenge this long held belief was Walker (1985 and 1986), who suggested that there were other possible anemic explanations, such as long-term breastfeeding and diarrheal infections, based on his investigations of modern American Southwest societies and other prehistoric populations outside the American Southwest. Nutritional deficiencies (Folic Acid, Vitamin C and B_{12}), hereditary factors (i.e. sickle cell anemia), parasitic load, and infectious disease have all been proposed as possible explanation for the occurrence of cribra orbitalia and porotic hyperostosis (Wapler et al. 2004).

All of the subadults skeletal remains from the STC, HK43, SMC, and CGC mortuary samples were examined for the presence of cribra orbitalia and porotic hyperostosis. Lesions were recorded as being present, absent, or unobservable. Individuals that were unobservable were removed from the original growth sample, and a new pathological subsample was created from the observable individuals. If the lesions were present, then it was determined whether the lesion was active, in the process of healing, or had healed prior to the time of death. However, this determination was not always possible in the comparative samples because the state of the lesion was not recorded during the original skeletal analysis. In the HK43, STC, and CGC samples, this difficulty only occurred with one individual from each site. The SMC data sheets listed the type of lesion based on Stuart-Macadam typology (1991), but did not record whether the lesions were active, healing, or healed during the skeletal analysis for any of the subadults that reported having cribra orbitalia or porotic hyperostosis. This limits any comparison that can be made using the SMC subadult sample.

Table 23 lists the number of subadults from the STC, HK43, SMC, and CGC samples that were identified as having cribra orbitalia, as well as those identified with porotic hyperostosis lesions. Seventy three percent the observable subadults from the STC had cribra orbitalia, indicating high prevalence of anemia within this population. When percentages are compared between the comparative cemetery samples there is a significantly higher percentage of individuals with cribra orbitalia at the STC than at HK43 (Fisher's Exact Test, p value < 0.001), SMC (Fisher's Exact Test, p value < 0.001), and CGC (Fisher's Exact Test, p value < 0.001). The occurrence of porotic hyperostosis was low in all of the mortuary samples. The SMC reported no cases of porotic hyperostosis. The STC reported the most incidences of porotic hyperostosis with three cases but it was only 4.6% of the sample. HK43 and CGC both only reported two individuals, which was 10.0 % and 7.0 % of their respective samples.

Table 23- The number and percentage of subadults with cribra orbitalia and porotic hyperostosis from the subadult mortuary growth samples.

Pathology	Cribra Orbitalia			Porotic Hyperostosis		
Subsample	n	#	%	n	#	%
STC	63	46	73.0%	66	3	4.6%
HK43	20	5	25.0%	20	2	10.0%
SMC	61	15	24.6%	61	0	0%
CGC	28	7	25.0%	28	2	7.0%

Table 24 shows the breakdown of the cribra orbitalia and porotic hyperostosis lesions by age groups, as well as the total number of active, healed, and healing lesions for the STC subadult sample. Researchers were only able to determine if a cribra orbitalia lesion was healing or healed for one individual from STC. The occurrence of cribra orbitalia was high in all age groups. Of the cases of cribra orbitalia reported at the STC, 65.2% were active lesions at the time of death. The percentage of active cases differed between the Amarna age groups. Over 80% of the cases of cribra orbitalia in infants were recorded as having active lesions of cribra orbitalia. The toddler stage reported the most incidences of active cribra orbitalia, and all the cribra orbitalia reported for the toddler stage was active at the time of death. The early childhood and late childhood stages reported more cases of individuals that had healing or healed lesions than the earlier age categories. The early childhood and late childhood age groups both had low percentages of active lesions with 41.7% and 58.3% of the cases being active within these age categories. The three individuals who had porotic hyperostosis from the STC sample were two toddlers and one early child. All three incidences of porotic hyperostosis were active at the time of death. All three individuals who reported having porotic hyperostosis also had active cribra orbitalia.

Table 24: The prevalence of cribra orbitalia and porotic hyperostosis lesions divided by age groups and includes the number of lesions from the STC that were scored as active (A), healing (Hg), or healed (Hd).

STC	Cribra Orbitalia						Porotic Hyperostosis					
	n	#	A	Hg	Hd	No Score	n	#	A	Hg	Hd	No Score
Infant	9	6 (66.7%)	5	0	1	0	8	0 (0%)	0	0	0	0
Toddler	17	13 (76.0%)	13	0	0	0	18	2 (11.1%)	2	0	0	0
Early Child	16	12 (75.0%)	5	3	4	0	18	1 (5.6%)	1	0	0	0
Late Child	21	12 (71.4%)	7	2	5	1	22	0 (0%)	0	0	0	0
Total	63	46	30	5	10	1	66	3	3	0	0	0

Table 25 presents the prevalence and state of the cribra orbitalia and porotic hyperostosis in the HK43 subadult sample based on age groups. Three incidences of cribra orbitalia were reported as being active and one was in the process of healing. Only one case from the HK43 subadult sample did not include the state of the lesion. Generally, the HK43 subadults were less likely to be suffering from cribra orbitalia than the STC sample individuals were. The late childhood age groups had the highest occurrence of cribra orbitalia, as well as the greatest number of active cases than any of the other stages. No cases of cribra orbitalia were reported among the infants of HK43, and only a single case was reported for both the toddler and early childhood age categories.   The two incidences of porotic hyperostosis reported at the HK43 cemetery samples were one infant and one early child. Both cases of porotic hyperostosis were active at the time of death. Only one of the individual from the HK43 cemetery reported having both cribra orbitalia and porotic hyperostosis. Both lesions were active at the time of death.

Table 25: The prevalence of cribra orbitalia and porotic hyperostosis lesions divided by age groups and the number of lesions from HK43 scored as active (A), healing (Hg), or healed (Hd).

HK43	Cribra Orbitalia						Porotic Hyperostosis					
	n	#	A	Hg	Hd	No Score	n	#	A	Hg	Hd	No Score
Infant	2	0 (0%)	0	0	0	0	2	1 (50%)	1	0	0	0
Toddler	5	1 (20%)	0	1	0	0	5	0 (0%)	0	0	0	0
Early Child	6	1 (16.7%)	1	0	0	0	6	1 (16.7%)	1	0	0	0
Late Child	7	3 (42.9%)	2	0	0	1	7	0 (0%)	0	0	0	0
Total	20	5	3	1	0	1	20	2	2	0	0	0

Table 26 shows the distribution of cribra orbitalia cases based on age groups in the SMC subadult sample. Whether the cribra orbitalia lesion was active, healing, or healed was not recorded for any of the subadults from the SMC mortuary sample during analysis. The early childhood age group had the greatest number of cribra orbitalia cases than any other age category. Fifty percent of the cribra orbitalia cases identified were individuals from the early childhood age group. The number of individuals with cribra orbitalia was consistent and low in the other age groups. No cases of porotic hyperostosis were reported in the SMC subadult sample data sheets.

Table 26: The prevalence of cribra orbitalia and porotic hyperostosis lesions divided by age groups and includes the number of lesions from the SMC that were scored as being active (A), healing (Hg), or healed (Hd).

SMC	Cribra Orbitalia						Porotic Hyperostosis					
	n	#	A	Hg	Hd	No Score	n	#	A	Hg	Hd	No Score
Infant	14	2 (14.3%)	0	0	0	2	14	0 (0%)	0	0	0	0
Toddler	15	3 (20.0%)	0	0	0	3	15	0 (0%)	0	0	0	0
Early Child	20	8 (40.0%)	0	0	0	8	20	0 (0%)	0	0	0	0
Late Child	12	2 (16.7%)	0	0	0	2	12	0 (0%)	0	0	0	0
Total	61	15 (24.6%)	0	0	0	15	61	0 (0%)	0	0	0	0

Table 27 displays the prevalence of cribra orbitalia and porotic hyperostosis in the CGC subadult sample divided based on age stages, as well as whether the lesions were active, healing, or healed at the time of death. The majority of incidence of cribra orbitalia and porotic hyperostosis were identified in the infant and toddler age groups, except for one case of cribra orbitalia in the late childhood age category. No cases were reported among the subadults in the early childhood age group. Only one individual did not have the state of the lesions recorded during analysis, and this individual was from the late childhood stage. Infants reported three cases of active cribra orbitalia and one case of these was in the process of healing. All cases of toddler cribra orbitalia were active at the time of death. The CGC also reported two cases of porotic hyperostosis with one individual in the infant age group and the other from the toddler age stage. All incidences of porotic hyperostosis were active at the time of death. Both individuals identified with active porotic hyperostosis also had active cribra orbitalia at the time of death.

Table 27: The prevalence of cribra orbitalia and porotic hyperostosis lesions divided by age groups and includes the number of lesions from the CGC that were scored as being active (A), healing (Hg), or healed (Hd).

CGC	Cribra Orbitalia						Porotic Hyperostosis					
	n	#	A	Hg	Hd	No Score	n	#	A	Hg	Hd	No Score
Infant	14	3 (21.4%)	3	0	0	0	14	1 (7.1%)	1	0	0	0
Toddler	5	3 (60%)	3	0	0	0	5	1 (20%)	1	0	0	0
Early Child	4	0 (0%)	0	0	0	0	4	0 (0%)	0	0	0	0
Late Child	5	1 (20%)	0	0	0	1	5	0 (0%)	0	0	0	0
Total	28	7 (25%)	6	0	0	1	28	2	2	0	0	0

Linear Enamel Hypoplasias

Linear enamel hypoplasias (LEHs) are horizontal defects caused by a disruption in the development of the tooth enamel. Stress episodes during an individual's life will cause amelogenesis in which enamel formation slows down or ceases, and will result in defects that can be observed on the surface of the teeth (Goodman and Rose 1990). Enamel formation slows or ceases because the physiological stress reduces or stops the ameloblasts from secreting enamel matrix (Hillson et al. 1998). LEHs are often used as nonspecific stress indicators to help identify periods of stress during the time of tooth formation in an individual's life (King et al. 2002). LEHs have often been used to identify periods of childhood stress in both clinical and osteological data (Acosta et al. 2003; Dolphin and Goodman 2002; Goodman and Rose 1990; Hillson et al. 1998; Knick 1982; Kreshover 1960; Kronfield and Schour 1939; Levine and Keen 1974; Noren et al. 1978; Rose et al. 1985; Sarnat and Schour 1941; Seow 1992; Sweeney et al. 1971). Researchers have found a correlation between this skeletal stress indicator and low life expectancy (e.g. Boldsen 2007; Blakely and Armelagos 1985; Cook and Buikstra 1979; Rose et al. 1978). Subadult and adult individuals with LEHs have been shown to consistently have a younger mean age of death than those who did not have these dental lesions (Blakely and Amelagos 1985; Cook and Buikstra 1979; Goodman and Amelagos 1988).

In the case of the STC population, the adults are unable to inform us about childhood stress episodes at Akhetaten due to the short occupation period of the city. Any individual older than approximate 17 years of age would not have grown up in the city, but were a part of an immigrant population that arrived after their permanent tooth formation. The LEHs identified in the adult skeletons can only tell us about childhood prior to the reign of Akhenaton and the inhabitation of Akhetaten. As the focus of this research is on life at Akhetaten during the reign of the pharaoh Akhenaton, only the occurrence of LEHs among the subadult skeletal remains from STC and the comparative mortuary samples were examined and analyzed in this project. During skeletal analysis, the presence or absence of LEHs were record for all mature dentition from the STC, HK43, SMC, and CGC subadult mortuary populations.

Table 28 shows the number of individuals identified in the mortuary samples that had at least one or more LEHs reported on a permanent tooth. Due to the lack of fully developed permanent dentition by the majority of individuals in these early age groups, infants, and toddlers were not included in the dental lesion analysis. The STC had the highest percentage of individuals with LEHs, indicating that the children of Akhetaten were more likely to have experienced stress episodes that resulted in the impediment of enamel formation during the early years of life than subadults from the other mortuary samples. The HK43 and SMC samples had almost equal percentages of subadults with LEHs. However, when the samples were divided by age groups the distribution of individuals with these dental lesions is not consistent between the samples. The HK43 sample has a slightly higher percentage of early childhood subadults with LEHs when compared to the STC and SMC samples. The CGC sample reported no dental lesion among the early childhood subadults. The SMC reported the highest percentage of LEHs among the Late Childhood group. The SMC and STC reported over 20% more late childhood LEHs than HK43 demonstrating a difference in the age of death for those with the dental lesion between the two samples. The CGC only reported one individuals with a LEH for their entire subadult skeletal sample. This individual was part of the late childhood age group. LEHs were more common in the late childhood age group than the early childhood age stage for all of the mortuary samples.

Table 28: The prevalence of LEHs among the subadult samples.

Age Groups	STC		HK43		SMC		CGC	
	N	#LEHs	N	# LEHs	N	# LEHs	N	# LEHs
Early Child	10	3 (30.0%)	6	2 (33.3%)	23	5 (21.7%)	4	0 (0%)
Late Child	28	23 (82.1%)	7	4 (57.1%)	18	15 (83.3%)	5	1 (20%)
Total	38	26 (68.4%)	13	6 (46.2)	41	20 (48.9%)	9	1 (11.1%)

Deciduous dental data was not part of the original research objectives for the STC, HK43, and CGC investigations. Data for deciduous LEHs was not systematically collected during the skeletal analyses for any of these subadult skeletal samples (J. C. Rose, personal communication, April 16, 2018). Therefore, no deliberate attempt was made to record the presence, or absence of LEHs in deciduous dentition for three of the four comparative skeletal populations. No deciduous LEHs were mentioned in any of the data analysis sheets for the HK43 subadult sample. Only a single individual, a one and half years old from the CGC sample reported having severe hypoplasias on their deciduous dentition. By chance, four individuals were recorded as having LEHs on their deciduous dentition during the skeletal analysis for the STC sample. The deciduous LEHs were located on the mandibular and maxillary canines. Two of the individuals were 7.5 years old, and the others were 3.5 and 9.5 years old. Two of the individuals (7.5 and 9.5) reported with having LEHs on both their permanent and deciduous dentition indicting both prenatal and postnatal periods of stress. The formation of deciduous dentition primarily transpires intrauterine and is dependent on maternal health and nutrition (Lewis 2007). The presence of these dental lesions tentatively indicates poor maternal health among a few of the females from Akhetaten. Further research needs to be conducted to further evaluate the extent of the occurrence of LEHs among the STC subadults, which would provide robust evidence of the maternal health during pregnancy at Akhetaten.

Deciduous LEH data was methodically collected during the skeletal analysis of the SMC subadult data. The SMC reported the occurrence of prenatal LEHs in six of the subadults, which is approximately 15% of the subadult dental sample for this skeletal population. The ages of the individual with these dental lesions include 1.5 months, 1.5 years, 3.5 years, 6.5 years (2), and 9.5 years. The three older subadults were also reported as having LEHs on permanent dentition, as well as the deciduous LEHs indicating both prenatal and postnatal stress episodes transpiring. Poor maternal health was a limiting factor for survival among some of the SMC subadults, as it also appears to be the case with the STC sample.

Scurvy

Scurvy is a nutritional disorder that results from a vitamin C or ascorbic acid deficiency.

Symptoms can include lethargy, musculoskeletal pain and weakness, anemia, bleeding gums, and skin problems (Brickley and Ives 2008). Humans and other primates are some of the few organisms that are unable to synthesize and produce their own vitamin C (Stone 1965; Stuart-Macadam 1989). Due to vitamin C being a water-soluble compound, humans must consume foods that are high in the ascorbic acid on a daily basis, as it is necessary for growth and other basic metabolic functions of the body (Pimentel 2003). Fruits and vegetables are abundant sources for vitamin C, and small amounts can be obtained from milk, meats, and fish (Brickley and Ives 2008). Human breast milk in particular is high in vitamin C, and the average levels are greater in human milk than cow's milk (Grewar 1965). The average daily requirement for vitamin C is 30 milligrams per day, although it has been shown that as little as 6.5 to 10 milligrams per day can prevent the onset of scurvy symptoms (Cheung et al. 2003: 248). Clinical studies have shown that the disease will begin to manifest when the individual has been deficient for 4-10 months (Ortner 2003).

Two types of scurvy have been distinguished from other incidences of the disease in subadult skeletal remains. The most common type of scurvy in children usually occurs between the ages of 6 months to two years, which is when vitamin C that was stored during gestation has become depleted (Lewis 2007). The depletion of these birth stores and the lack of nutritional complementary feeding can result in infantile scurvy or Möller-Barlow disease (Möller 1862; Barlow 1883; Lewis 2007). A rare form of the disorder is referred to as congenital scurvy, which develops before the age of 6 months in newborns and young infants (Brickley and Ives 2008). Congenital scurvy has more to do with maternal health during pregnancy and nutrients available in the breast milk or milk substitute provided than with the infant. Pregnancy increases the daily requirement to as much as 70 milligrams per day, whereas lactation can necessitate as much as 90 milligrams of vitamin C per day (Pimentel 2003). If the mother is deficient then the newborn will have little to no vitamin C stored after birth, which can then be further exacerbated by poor ascorbic acid levels in the breast milk or feeding substitute (Fain 2005). Premature, low-birth weight babies, and twins are more likely to become vitamin C deficient during lactation (Griffith 1919).

In terms of growth and development, vitamin C is essential for the production of Type 1 collagen, which is the most abundant collagen in the human body (Jaffe 1972; Lewis 2007). Type 1 collagen is the protein matrix for many of the connective tissues found in the skin, blood vessels, cartilage, and bone (Stuart-Macadam 1989). Osteoblasts are bone cells that are responsible for the creation of new bone through excretion of osteoid, an "organic bone matrix" that is made up of 94% collagen fibers (Brickley and Ives 2008: 30). Scurvy can cause a reduction or cessation of osteoblastic activity in children, which can then result in the inability to produce osteoid (Brickley and Ives 2008; Fain 2005). Without the production of osteoid, new bone formation will halt, which will delay growth until vitamin C is reintroduced. Once ascorbic acid is reintroduced into the diet then osteoid production will be initiated allowing for new bone formation to occur in areas that have had sub-periosteal bleeding (Brickley and Ives 2008).

It is these new bone formations and incidences of porosity at specific locations that are used to diagnose scurvy in subadult skeletal remains. Table 29 lists the location site of the new bone formation and porosity along with other associative features that are indicative of scurvy from the paleopathological literature. However, other conditions can result in similar skeletal lesions, such as anemia, rickets, trauma, periosteal disease, and infection (Brickley and Ives 2008). Normal growth process can even sometimes create lesions that look similar to scurvy and can make the differential diagnosis of scurvy difficult in subadults undergoing rapid growth.

The scurvy data used in this research was collected from the original data sheets and relies on the diagnosis of scurvy in the field. This diagnosis often includes individuals that were listed as having "possible" scurvy. As an in-depth paleopathological assessment of the individual sites was not possible, the percentages presented here are an approximation of the number of individuals afflicted with scurvy.

Table 29: Sites of new bone formation and porosity used to diagnose scurvy in subadult skeletal remains. Additional features associated with the identification of scurvy have are also listed. Lewis (2007) and Brickley and Ives (2008) were used to create the list of diagnostic features.

Sites of New Bone Formation and Porosity Indicative of Scurvy
Cranial vault: parietal, occipital, temporal
Greater wing of the sphenoid
Orbital roof of the frontal
Zygomatic bone: orbital process and internal aspect
Maxilla: posterior aspect, palate, infraorbital foramen
Coronoid process of the mandible
Supraspinous and infraspinous processes of scapula
Metaphysis region of the long bones
Pelvis (not common)
Additional Features Associated with Scurvy
Loosening of Dentition
Antemortem tooth loss
Scorbutic Rosary of Ribs
Thickening of bones

Table 30 shows the number of individuals identified with scurvy from the comparative subadult samples, as well as the distribution of occurrences across the age categories. The STC reported the highest number of individuals with signs of scurvy when compared to the other subadult mortuary samples. Approximately 23% of the subadults from the STC reported having scurvy, whereas no cases were reported in the sample taken from HK43 mortuary population. The STC sample was the only population to report individuals with scurvy in all age groups, as well as the only one to report any incidences among the late childhood age group. However, the oldest individuals were less likely to be suffering from scurvy at the time of death than their younger counter parts. The infant age group had the highest percentage of incidences reported in the STC sample, which was followed by the early childhood age stage. The infants identified with scurvy had dental ages of 4.5 months and 7.5 months, which is consistent with both congenital and infant scurvy. Skeletal markers of scurvy reported in infants as young as 4.5 months is rare as the child is normally provided with enough vitamin C from the mother for the first 6 months of life (Fain 2005). This suggests poor maternal health for the STC population that is further supported by the presence of deciduous LEHs and cribra orbitalia among these very young infants. Individuals from the SMC and CGC reported low incidences of scurvy in their subadult population. One of the individuals from SMC who reported having scurvy was estimated to be 7.5 months old, while the other two had a dental age of 1.5 years. The ages of these incidences are consistent with infancy scurvy. The CGC reported two individuals with scurvy. One individual is listed as “possible scurvy” was a 1.5-month-old infant, which is extremely young to be showing diagnostic features associated with scurvy. The other subadult that reported having scurvy at CGC was a 6.5 year old.

Table 30: Prevalence of Scurvy in the STC, HK43, SMC, and CGC subadult samples.

	STC		HK43		SMC		CGC	
	N	# Scurvy	N	# Scurvy	N	# Scurvy	N	# Scurvy
Infant	9	5 (55%)	2	0 (0%)	13	1 (7.7%)	14	1 (7.0%)
Toddler	17	4 (17.5%)	5	0 (0%)	15	2 (13.3%)	5	0 (0%)
Early Childhood	19	5 (26.3%)	6	0 (0%)	21	0 (0%)	4	1 (25%)
Late Childhood	27	3 (11.1%)	7	0 (0%)	12	0 (0%)	5	0 (0%)
Total	72	17 (23.6%)	20	0 (0%)	61	3 (4.9%)	28	2 (7.0%)

Rickets

Rickets is a metabolic condition that is normally brought on due to a deficiency in vitamin D (Brickley and Ives 2008). Unlike ascorbic acid, vitamin D is produced internally when skin is exposed to ultraviolet (UV) light and interacts with 7-dehydrocholesterol (Lewis 2007). The production of vitamin D by UV light exposure accounts for the majority of the mineral supply used by the body (Brickley and Ives 2008). Fraser reports that small amounts of vitamin D can be obtain from food sources, such as fish oil, liver, and eggs (1995). A lack of exposure to sunlight and poor nutrition are common causes for vitamin D deficiency in past populations (Mays et al. 2006). For the first 6 months of life, neonates are dependent on vitamin D that they stored during the last two months of gestation (Arneil 1973). After six months, the child must be exposed to the sun in order to begin generating its own vitamin D (Foote and Marriott 2003).

Skeletal health, immune reaction, mineral metabolism, and cell growth are just of the few vital metabolic processes that requires vitamin D (Brickley and Ives 2008). The manifestation of rickets in subadults exhibits differently than osteomalacia in adults due to the influence the mineral deficiency has on the skeletal growth of the subadult (Lewis 2007). Vitamin D is essential for the mineralization of osteoid that is required for normal growth and maintenance of the skeleton (Pitt 1988). This can result in the skeleton becoming compromised and malleable under pressure as it develops (Lewis 2007). These bones become prone to weakness under stress, which leads to deformities and fractures in children (Brickley and Ives 2008; Mankin 1974). This mineral deficiency will also affect the growth plates of skeletal elements, as this is a major site of osteoblast and chrondroblast activity (Lewis 2007). Table 31 is list of diagnostic and common features that are associated with the rickets complex in children, which are compiled from Lewis (2007) and Brickley and Ives (2008). Differential diagnosis of rickets has shown that other conditions can have similar effects on the skeleton, such as scurvy, osteopenia, anaemia, normal growth, Blount's disease, trauma, and various childhood illnesses (Brickley and Ives 2008). Children who are suffering from a protein-calorie deficiency called Marasmus will not demonstrate any signs of rickets until the macromolecule is reintroduced into the diet (Griffith 1919). The symptoms of rickets can also be the result of deficiencies in calcium and/or phosphorus (Fraser 1995).

The incidences of rickets reported in this chapter were collected from the original data sheets and rely solely on the original diagnosis of the condition during skeletal analysis. These diagnoses often include individuals that were listed as having "possible" rickets. Some individuals were even listed as having either scurvy or rickets, therefore, these percentages should be taken as estimations of the frequencies of rickets in these skeletal populations. An in-depth paleopathological assessment needs to be conducted for the STC sample to make a final determination of these diagnoses.

Table 31: A list of diagnostic features and additional changes that can be associated with the identification of rickets. Lewis (2007) and Brickley and Ives (2008) were used to create the list of diagnostic features.

Diagnostic Features of Rickets
New bone formation and porosity on cranial vault
Medial angulation of the mandible
Expansion and fraying of rib ends
Rib angulation and sternum protrusion
Kyphosis or scoliosis
Fraying, flaring, and swelling of the metaphases
Bending or bowing of the long bones
Thickened long bones, ilia, and scapulae
Angulation of femoral head
Porosity and cupping deformities along growth plate
Additional Features Associated with Rickets
Fontanelle closure delayed
Delay in dental eruption
Parietal and frontal bossing
Thinning cranial bones
Linear enamel hypoplasias
Fractures, growth deformities, stunting
osteopenia

The number of rickets cases and the incident frequencies are listed in table 32 for all of the subadult skeletal samples. It also includes the distribution of rickets across the age categories used in this research project. No cases of rickets were reported for the HK43 cemetery during the skeletal analysis. Individual 91 from the STC skeletal population was originally diagnosed with possible scurvy or rickets. The author and Dr. Rose determined that this individual's lesions were more consistent with scurvy than rickets based on the descriptions and photographs taken during analysis (J. C. Rose, personal communication, August 13, 2017). No other individual from the STC subadult growth sample reported having rickets at the time of death. CGC reported only one individual with rickets and this individual was 1.5 years old. The SMC growth sample reported the highest percentage of frequency for all of the samples with 20% of the subadults having rickets. All of the age groups are represented among the aflicted with the toddler age stage having the highest number of individuals with rickets. Rickets was diagnosed in a 4.5-month-old infant, which further provides evidence of poor maternal health in the SMC mortuary sample.

Table 32: Prevalence of Rickets in the STC, HK43, SMC, and CGC subadult samples.

	STC		HK43		SMC		CGC	
	N	# Rickets	N	# Rickets	N	# Rickets	N	# Rickets
Infant	8	0 (0%)	2	0 (0%)	26	4 (15.4%)	14	0 (0.0%)
Toddler	17	0 (0%)	5	0 (0%)	23	10 (43.5%)	5	1 (20%)
Early Childhood	18	0 (0%)	6	0 (0%)	23	3 (13.0%)	4	0 (0%)
Late Childhood	27	0 (0%)	7	0 (0%)	18	1 (5.6%)	5	0 (0%)
Total	70	0 (0.0%)	20	0 (0%)	90	18 (20.0%)	28	1 (4.0%)

Growth and Health

The previous sections of this chapter have provided detailed examinations of common pathological lesions and disorders associated with childhood health that were identified in the STC, HK43, SMC, and CGC subadult growth samples. In order to understand the impact these pathological conditions had on the growth of the subadults in the comparative samples, δlimeans were calculated for individuals with and without these pathologies. Age group δlimeans were also calculated for each age group depending on whether the subadults had, or did not have the pathological condition. These values are listed in tables 33 through 36 for all of the subadult mortuary samples. Some comparisons were not possible due to the lack of representation of the pathological conditions in certain age groups or samples, and are indicated by a diagonal line in the tables below. When examining the pathological scores for the total STC sample, lower δlimean values were reported in individuals with LEHs and porotic hyperostosis (PH) than those who did not have these lesions. This was not the case for individuals with cribra orbitalia (CO) or scurvy. These individuals had higher δlimeans than those who did not have a pathological conditions. When the samples were divided into age groups, a pattern appeared in the STC sample. The younger categories (infant and toddler) had higher δlimeans among the aflicted, whereas the older age groups (early childhood and late childhood) tended to have lower δlimean for individuals with the conditions. A possible explanation for this may be the factor of time, as older individuals have lived longer allowing for a greater growth disruption. All of the conditions reported at HK43 had lower δlimeans among individuals with the pathological disorder. Only the toddlers with cribra orbitalia reported having higher δlimean values when compared to subadults who did not have the pathology. However, this is still consistent with the pattern identified among the STC sample. The SMC sample also had lower δlimean values for all of their pathological conditions reported, except for LEHs. However, this is due to a difference in age group size within the non-aflicted groups. There are only three individuals representing the late childhood group without LEHs when compared to the 18 early childhood individuals with LEHs. When the SMC LEH sample is divided in to age categories, all age groups reported lower δlimean values among individuals with LEHs than those without. The SMC tended to report lower δlimean among individual with pathological conditions than those without no matter the age. This was not the case for the CGC pathological samples. All of the conditions reported at CGC had higher δlimeans among individuals with the pathological disorder. Only toddlers with porotic hyperostosis reported having lower δlimean values than those that did not have the pathological lesion. The pathological conditions used in this analysis tended to be much lower in the CGC sample when compared to the other samples, which is consistent with the reported higher values of achieved growth for this mortuary sample.

Table 33: δlimeans are listed for the STC subadult individuals with and without pathological conditions identified in the skeletal population. With and without pathological δlimeans are included in the chart for each age group. The lowest pathological δlimeans are highlighted in gray indicating poorer achieved growth among these individuals. The squares with the diagonal lines indicate that no comparison could be made.

STC Subadult Sample	**CO**		**PH**		**LEH**		**Scurvy**		**Rickets**	
	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without
Infant	-0.022	-0.029					-0.009	-0.044		
Toddler	-0.064	-0.078	-0.067	-0.069			-0.046	-0.074		
Early Childhood	-0.052	-0.080	-0.105	-0.055	-0.056	-0.029	-0.080	-0.047		
Late Childhood	-0.047	-0.039			-0.051	-0.033	-0.133	-0.045		
Total	-0.049	-0.055	-0.075	-0.050	-0.051	-0.031	-0.046	-0.053		

Table 34: δlimeans are listed for the HK43 subadult individuals with and without pathological conditions identified in the skeletal population. With and without pathological δlimeans are included in the chart for each age group. The lowest pathological δlimeans are highlighted in gray indicating poorer achieved growth among these individuals. The squares with the diagonal lines indicate that no comparison could be made.

HK43	**CO**		**PH**		**LEH**		**Scurvy**		**Rickets**	
Subadult Sample	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without
Infant			-0.099	-0.035						
Toddler	-0.015	-0.058								
Early Childhood	-0.078	-0.034	-0.078	-0.034	-0.086	-0.037				
Late Childhood	-0.05	-0.029			-0.037	-0.034				
Total	-0.048	-0.035	-0.083	-0.034	-0.046	-0.036				

Table 35: δlimeans are listed for the SMC subadult individuals with and without pathological conditions identified in the skeletal population. With and without pathological δlimeans are included in the chart for each age group. The lowest pathological δlimeans are highlighted in gray indicating poorer achieved growth among these individuals. The squares with the diagonal lines indicate that no comparison could be made.

SMC	**CO**		**PH**		**LEH**		**Scurvy**		**Rickets**	
Subadult Sample	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without
Infant	-0.043	-0.060					-0.039	-0.059	-0.069	-0.042
Toddler	-0.096	-0.038					-0.121	-0.055	-0.063	-0.061
Early Childhood	-0.057	-0.085			-0.075	-0.074			-0.107	-0.068
Late Childhood	-0.099	-0.044			-0.055	-0.025			-0.041	-0.051
Total	-0.071	-0.059			-0.059	-0.069	-0.098	-0.064	-0.074	-0.056

Table 36: δlimeans are listed for the CGC subadult individuals with and without pathological conditions identified in the skeletal population. With and without pathological δlimeans are included in the chart for each age group. The lowest pathological δlimeans are highlighted in gray indicating poorer achieved growth among these individuals. The squares with the diagonal lines indicate that no comparison could be made.

CGC Subadult Sample	**CO**		**PH**		**LEH**		**Scurvy**		**Rickets**	
	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without	δlimean With	δlimean Without
Infant	0.019	-0.033	0.038	-0.029			0.038	-0.029		
Toddler	0.007	-0.046	-0.012	-0.006					-0.001	-0.009
Early Childhood							0.016	-0.033		
Late Childhood	0.029	-0.005			0.016	0.001				
Total	0.015	-0.015	0.008	-0.017	0.016	-0.015	0.026	-0.019	-0.001	-0.015

Conclusion

This chapter has reviewed the general health of the subadults from the STC, HK43, SMC, and CGC mortuary samples. The analysis focused on the number of occurrences and frequency of occurrence of various types of pathological conditions. The non-specific skeletal stress markers and metabolic disorders examined in this investigation included cribra orbitalia, porotic hyperostosis, LEHs, scurvy, and rickets. The STC reported the highest percentage of cribra orbitalia for all of the skeletal samples. The occurrence of porotic hyperostosis was extremely low amongst all the skeletal samples. High frequencies of LEHs on the permanent dentition were reported for all of the subadult samples, except for the CGC subadults. The identification of LEHs on deciduous dentition suggest poor maternal health in the STC, SMC, and CGC skeletal populations. The STC reported the greatest number of individuals with scurvy, whereas the SMC reported the highest occurrence of rickets. The manifestation of these conditions generally resulted in lower δlimeans in three of the subadult samples, but not in the CGC sample. These findings will be used to complete the biocultural stress models, and the results will be interpreted in the next chapter.

Chapter VIII

Biocultural Models of Childhood Stress

Good-Null states that “it is easy to become enmeshed with the biological aspects of analysis without adequately making connections to sociocultural aspects or histories of populations” (2002: 71). This chapter will endeavor to connect the historical, social, and environmental contexts of the mortuary samples to the physiological responses identified in the subadult skeletal remains. Historical and contextual data has already provided valuable information on the environmental constraints and social stresses, as well as providing evidence of cultural buffering systems identified in the STC, HK43, SMC, and CGC populations that were selected for the research project. The physiological and biological responses of the subadults were evaluated by conducting an osteological assessment of childhood growth and health (Chapters VI and VII). Individual biocultural models of childhood stress were created for each subadult mortuary sample using the information obtained from the historical reviews and osteological analyses. These frameworks are then used to interpret the childhood physiological responses within the parameters of their unique cultural and physical contexts. The connections identified in each population sample are used to compare and evaluate the lives of the children growing up in Akhetaten during the reign of the pharaoh Akhenaten. Prior to the analysis and creation of the stress models, the following hypotheses were made by the author:

1. Poor growth and higher frequencies of childhood stress markers will be seen in populations during major political, economic, and social shifts/conflicts.
2. Fluctuation in growth will be seen during periods of high stress associated with disease and poor nutrition, or during certain life history stages (e.g. weaning, puberty) in the

South Tombs Cemetery and comparative samples.

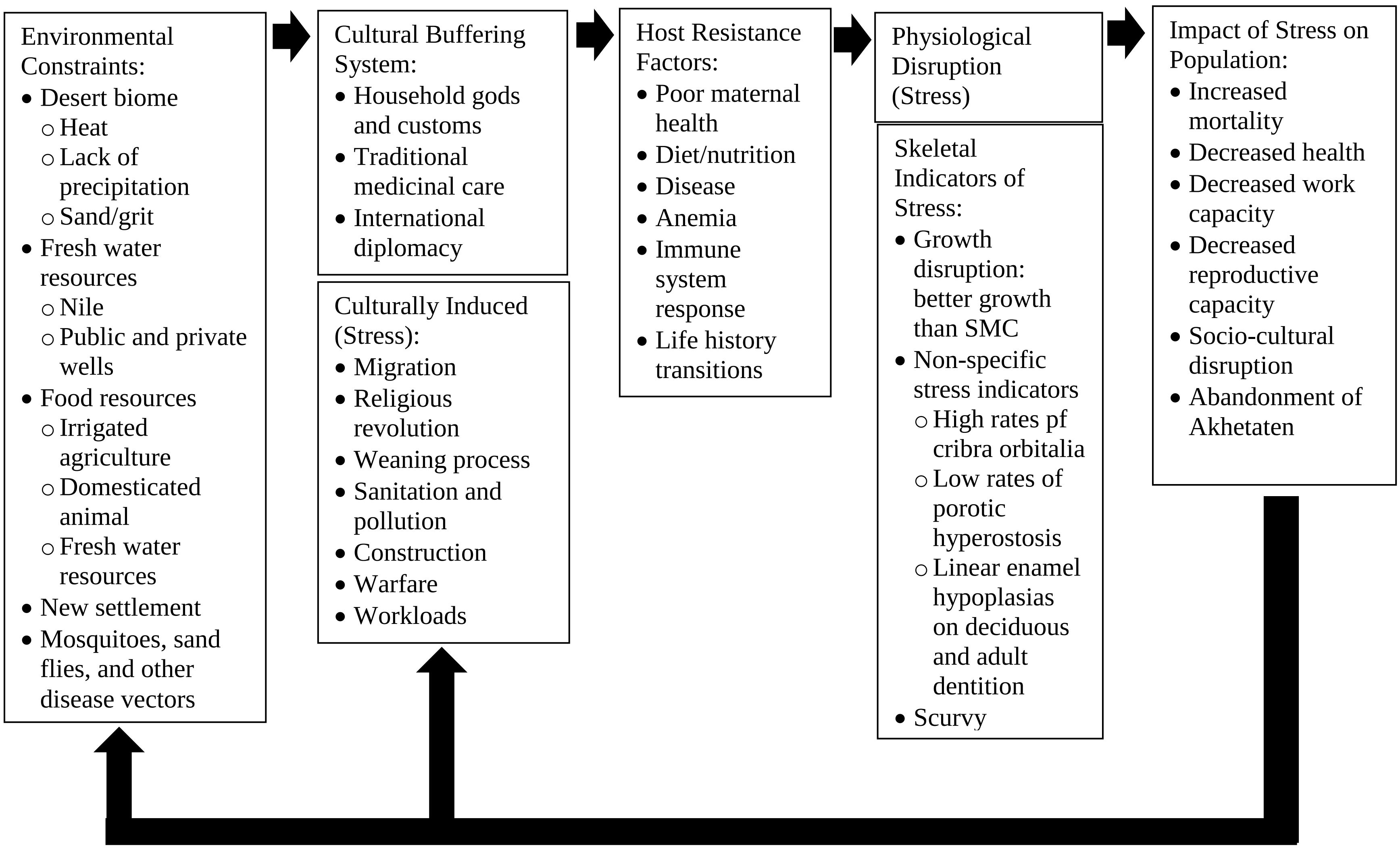
3. Transitional periods between life history stages will be reflected in the growth profiles as fluctuations; both negative and positive changes will be seen depending on the stage. Differences in the timing of these transitions will reflect a biological response to periods of both physiological and social stress.

These hypotheses are used to guide the final discussion and comparison of the mortuary samples.

Children and Childhood in Akhetaten, Egypt

Figure 17 is the biocultural model of childhood stress for the STC subadult skeletal sample. Akhetaten represents a new settlement that was quickly built and promptly inhabited by a large population at the decree of the ruling monarch. This population was already in the process of a social, political, and religious upheaval that had been implemented by the current pharaoh, which would have been exacerbated by the physical migration of this population to an undeveloped land. Although claims on whether or not this movement was voluntary cannot be made, it still created a massive burden on the immigrating population due to the physical and psychological demands of migration. These demands may have directly affected the health of the children as they traveled to their new city, or indirectly affected them through poor maternal health as their mothers experienced the ramifications of relocation. The population would also be susceptible to high rates of post-migration stress as the population attempted to adjust to their new surroundings.

Figure 17: South Tombs Cemetery's Biocultural Model of Childhood Stress.



The construction of the city would have been a constant factor in their physical environment throughout the entire occupation period, which created a high demand for physical labor. Kemp estimates that only about half of the city is made-up of residential houses, which he then states is an over estimation as there is evidence of manufacturing associated with many of these areas (2012:281). Stevens and Eccleston state that "in a sense, the Amarna suburbs appear as a vast but loosely structured factory serving the state" (2007:151). Pollution associated with manufacturing and construction would have impacted the health of the population. Additionally, poor sanitation would have been a major factor associated with the continuously growing population. Kemp refers to Akhetaten as an urban village that was "a dense world of personal contact, a human hive" with its closely located interconnected houses (2012: 299). The lack of distinction of wealth or status among neighborhoods would have also allowed for quick transmission of diseases and their agents among all members of Akhetaten's population due to this close contact.

The access to fresh water in this desert environment would have been a major part of daily life as well. Although the Nile represented the major fresh water resource for the agricultural fields, private and public wells supplied much of the water for domestic use in the city (Kemp 2012). Water pits were dug deep below the desert sands to reach the water table. The collection of water would have been a demanding process, as it had to be carried up spiral mudbrick staircases in containers. These fresh water resources would have also been a hazard to the health and well-being of the local population. Any standing water would have been a breading zone for mosquitoes, bacteria, and other disease causing agents. As the population grew and sanitation became poorer, the local water supplies could have quickly become contaminated.

Social and cultural support mechanisms are key to an individual's ability to appropriately respond to "harsh life situations" (Xi 2014: 1655). Both the migration and religious revolution would have destabilized many of the traditional cultural buffering systems that existed prior to the reign of Akhenaten. However, the archaeological evidence of traditional household gods associated with the home, fertility, pregnancy, children, and motherhood suggest that some of these cultural support systems were still active among the people of Akhetaten. In addition, international diplomacy continued throughout most of Akhenaten's reign, which would have reduced stress associated with warfare and physical conflicts.

It is within this environmental and sociocultural context that the STC's subadults would have been born and grown up. The infants of the STC had better achieved skeletal growth compared to the other age groups, which suggests that these infants had started life with overall good health. However, the occurrence of scurvy and LEHs in deciduous dentition, along with high rates of active cribra orbitalia suggest that gestation and early infancy were periods of high childhood stress. The STC had relatively few infant remains when compared to the other age groups. As previously mentioned, this may be due to them being buried in a different location, but this is doubtful, as only a couple of subadult remains have been found to date outside the cemeteries (J. C. Rose, personal communication, February 16, 2018). The low representation could imply that despite this being a period of stress more subadults were surviving infancy than dying. The abundance of written texts on childbirth, pregnancy, and breastfeeding suggest that there was a strong sociomedical support system to ensure the health and well-being of both mother and infant in Egyptian society (Janssen and Janssen 2007; Vymazalová and Strouhal 2014). The identification of traditional household gods suggests that these customs and practices were continued at Akhetaten and may have led to a higher survival rate among the infants of the STC.

After the first 7.5 months of life, there is a drop in achieved growth in the STC subadults, which indicates poor health among the individuals that were transitioning into the toddler age stage. The rate of cribra orbitalia lesions increases by approximately 10% in the toddlers, all of which were active at the times of death. Diagnostic features of scurvy continue to be identified among individuals in the toddler age group. The number of subadult skeletons representing this age stage has almost doubled from infancy to toddlerhood. The toddler stage is especially significant as it represents the life history trait of transitioning from breast milk to solid foods. The nutritional requirements among the younger age groups are high due to the energy demanded for rapid skeletal and brain growth (Chierici and Vigi 1991). The fetus will accumulate a storage supply of vitamin D, vitamin C, iron, calcium, and zinc, which are used in addition to the nutrients provided by the mother's breast milk (Lewis 2007). These stores of nutrients usually becomes depleted around six months of age depending on maternal health, as well as the health and metabolic rate of the individual child. According to modern medicine, complementary feeding should begin at approximately six months with the introduction of solid food (Detttwyler and Fishman 1992). This is when the mother is unable to adequately meet the energy and caloric needs of the child through breast milk alone (Sellen 2006). One method of solid food introduction is through a process called "kiss-feeding" in which premasticated food is provided by the mother to the offspring (Konner 2005). The toddlers of the STC could have not received adequate nutrition prior to and during this age stage based on the occurrence of cribra orbitalia, scurvy, and poor achieved growth among these individuals. This age group also reported two of the three active cases of porotic hyperostosis that was otherwise a rare occurrence in the STC. This could be because the mother had not started supplementary feeding or that the solid food provided was lacking in the nutrients required by the growing child.

According to the Instructions of Ani, Egyptian women were only supposed to breastfeed for the first three years of life (Janssen and Janssen 2007:15). It is unlikely that the mothers of Akhetaten would have diverged from this practice unless they were experiencing certain circumstances such as concerns over poor milk supplies or the failing health of an infant or toddler. Breast milk provides passive immunity to the infant through the transfer of the mother's antibodies and IgA molecules (Lewis 2007). However, a mother who recently migrated to a new environment would still be trying to acclimatize and would not necessarily provide the correct immunity response for local pathogens and diseases. This could result in the child being prone to illness and the mother assuming something was wrong with her milk. Medical papyri have been found in Egypt that include methods and prescriptions through which a lactating mother could increase her breast milk flow, as well as cures for "bad milk" (Vymazalová and Strouhal 2014). This indicates that the Ancient Egyptian people were well aware of the issues associated with mothers and lactation.

STC shows evidence of poor maternal health, which would have been exacerbated by the nutritional demands of lactation. This then could have then resulted in either the use of breast milk substitutions (cow/goat milk), or the early introduction of solid foods, which would have only continued to hinder the growth and health of the developing infants and toddlers. If infants are introduced to solid food too early then they are at risk of suffering from short-term health effects, such as aspiration, poor caloric intake, digestive issues, poor growth rate, and exposure to environmental contaminants (Kuo et al. 2011). The timing of solid food introduction and the cessation of breasting feeding needs to be investigated further in the STC population, as this was a period of substantial childhood stress for the developing infants and toddlers.

The toddlers of Akhetaten would have also been in the process of developing their fine and gross motor skills (e.g. walking, running, picking things up) (Bogin 1997). Their risk of harm due to environmental factors would have been evolving and increasing during this age stage. They would have been in process of becoming independent moving agents experiencing their environmental and cultural landscapes from a new perspective for the first time. The dense urban village would have brought these children into constant contact with new environmental contaminants and hazards that were not previously part of their infant world. Poor sanitation, debris, and pollution would have been a result of the constant construction, manufacturing, and growing population. This exposure would have put the toddlers of Akhetaten at a higher risk of harm, disease, or death. However, the close-knit community would have acted as a possible buffer system by reducing the potential threat of danger. Older female siblings likely would have been given the task of watching their younger brothers and sisters thus providing additional kin support (Janssen and Janssen 2007).

All members of an Egyptian household were expected to contribute by doing chores and completing other household responsibilities. This would have would have started with small household chores beginning around the third year of life (Janssen and Janssen 2007). Both boys and girls would have had responsibilities, such as feeding animals, running errands, or other small chores around the house. The tedious and labor-intensive task of collecting water would have likely been among the chores given to these young individuals. However, not all their time was spent working. Play would have been a way for these children to learn and imitate social roles and customs. Currently, no evidence of play, toys, or child exclusive spaces have been identified at Akhetaten (Janssen and Janssen 2007; Kemp 2012; J. C. Rose, personal communication, April 28, 2018). This may be due to the inclusive connectedness of the city plan and interlocking houses, which made distinct individual spaces rare at Akhetaten.

Under a normal demographic profile, the number of subadult skeletal remains should be gradually decreasing with age due to the reduction of child mortality risk after infancy (United Nations 1955). However, the number of STC individuals from the toddler age group to the early childhood age group increases when there should be a decrease in mortality. There is little fluctuation in the rate of cribra orbitalia or scorbutic lesions between these age groups. There is, however, a decrease in the number of active cases, as well as the first cases of healed or healing cribra orbitalia lesions in the early childhood stage. Achieved growth among the early childhood individuals slowly improves as the subadult's dental age increases.

The largest represented dental age groups for the STC sample are the 2.5 year olds and the 6.5 year olds, which both represent life history transitional ages. The 2.5 year old dental age likely represents the final cessation of weaning and the possible extension of the child's domain through travel associated with chores, whereas the 6.5 year old dental age likely indicates further expansion of the child's sphere into the larger community of Akhetaten through school and apprenticeships. As previously mentioned, toddlers would have still been limited in their environment, which presumably was restricted to the household-neighborhoods and the movements of their caregivers. The travel demands of chores would have gradually expanded the child's world in early childhood by incorporating locations, like the workshops and other errand destinations. This would have been amplified with the transition into late childhood beginning at 6.5 years of age, as these children moved beyond their households towards becoming active member within the community. In Ancient Egyptian society this was the approximate age that young boys would have either begun school or started apprenticeships and young girls would have started participating in domestic activities (Janssen and Janssen 2007). Due to the high needs for a large manufacturing and construction workforce, child labor demand may have been high in Akhetaten. Evidence of labor demands are currently being investigated at Akhetaten (H. S. Davis, personal communication, April 28, 2018).

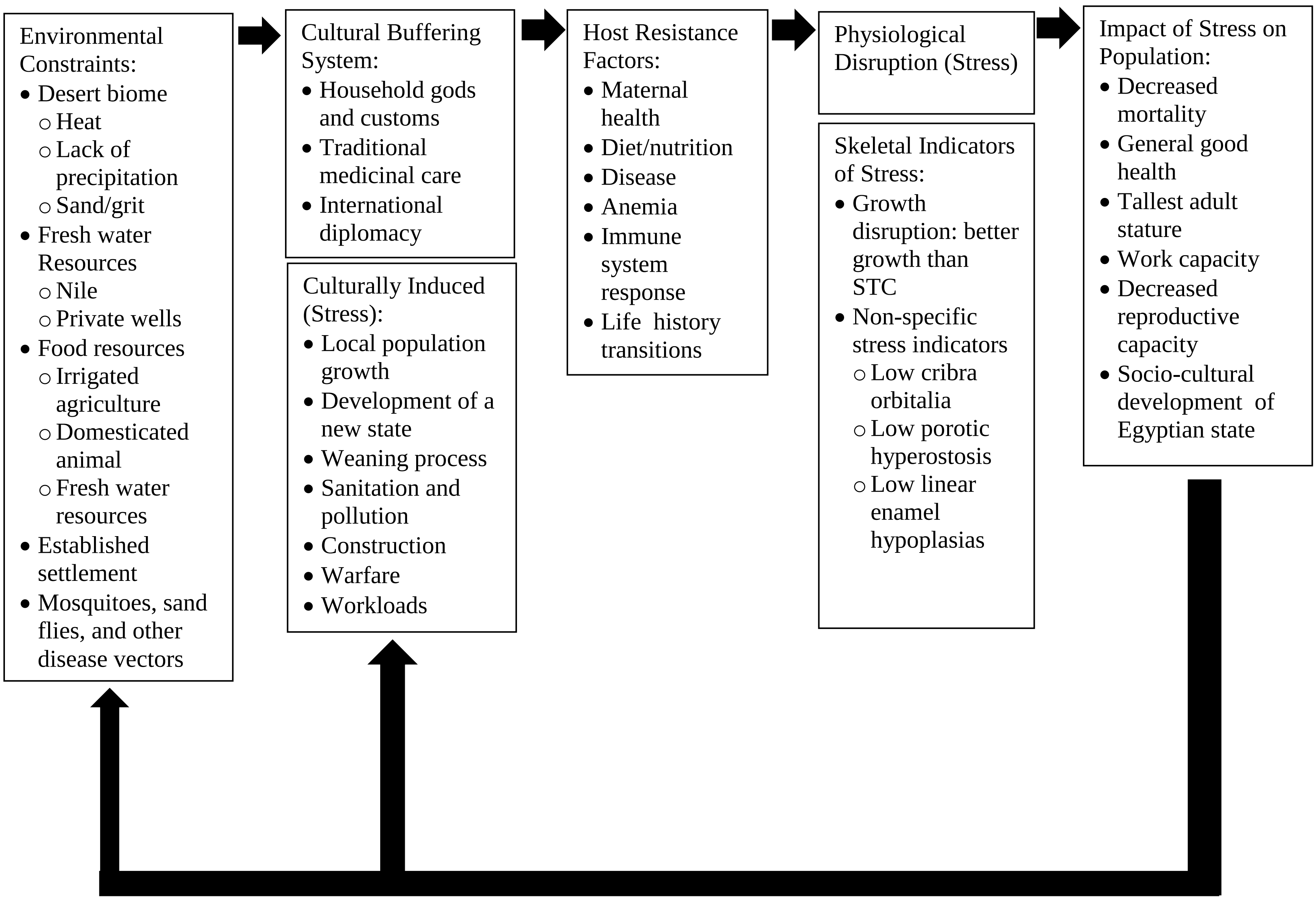
Finally, the late childhood age group includes a dental age range from 7.5 years to 14.5 years and is typically one of the healthiest periods in an individual's life (Cameron and Bogin 2012). However, the STC sample has a high occurrence of cribra orbitalia lesions amongst these subadults that is similar to the rates found in the younger age groups. Again, the majority of these lesions were active at the time of death. Three cases of scurvy are reported for this late childhood age group. The occurrence of LEHs on the permanent dentition was also high among these subadults, indicating that many of these individual also suffered from childhood stress episodes earlier in life. Individuals that reported having LEHs on their permanent dentition on average had lower achieved growth than individuals who did not. Achieved growth is better among the younger late childhood individuals (7.5 to 12.5 years old) than in the older late childhood individuals (13.5 to 14.5 years). These late subadults would be entering puberty and undergoing an adolescent growth spurt as they transition into adulthood. However, achieved growth is poorer in the 14.5 to 16.5 ages as these individuals transition into early adulthood. As previously mentioned, this is where there is the greatest difference in growth and development between the sexes. The sex of subadults cannot be determined. Yet, it was shown that use of female or male standards did not alter the findings of poor achieved growth among these older late childhood subadults and early young adults. The adult males and females from the STC have been shown to have some of the shortest femoral lengths when compared to other Ancient

Egyptian sites (Dabbs et al. 2015), which indicates poor health and childhood growth for this population. Exactly when an individual officially became an adult in Egyptian society is unknown. However, the transition into biological adulthood at Akhetaten appears to have been a challenging period for their subadults.

Children and Childhood in Hierakonpolis, Egypt

Figure 18 is the biocultural model of childhood stress for the HK43 cemetery from Hierakonpolis, which is being used to represent Pre-dynastic Egyptian childhood. This site represents a period of prosperity and innovation, as the sociocultural foundations for the developing Egyptian state were established. Hierakonpolis was a well-established settlement prior to becoming a regional capital, and the cemetery represents a long period of use (3600 – 3200 BCE). The population size for the city was small when compared with Akhetaten's population, as it only had max population 10,000 people. The low population would have decreased the effects of density-dependent limiting factors on health. Population growth was also gradual and locally based and was not the results of a mass migration into the area, indicating that this population was acclimatized to the local desert environment (Batey 2012; Irish 2006; Zakrzewski 2007). As a preindustrial population, food would have been a major factor in the health and well-being of the citizens of Hierakonpolis (Lee and Tuljapurkar 2008:473). New farming techniques and technologies would have resulted in better crop yields, which lead to better diets (Batey 2012). The city has been described as a developing nucleated village, and the Nile river valley allowed for expansion and movement of people with the development of Egyptian state (Batey 2012; Harlan, 1985). Pollution and poor sanitation would have been less problematic at Hierakonpolis due to the gradual growth of the city (Batey 2012).

Figure 18: HK43 Cemetery's Biocultural Model of Childhood Stress.



Previous studies conducted on HK43 reported good health for the general skeletal population and low occurrence of skeletal stress markers (Batey 2012; Greene 2006; Kumar 2009; Zabecki 2009). These findings are consistent with the results of the childhood stress and growth analyses conducted on the subadult remains from HK43. Only three infants were reported in the growth sample, and two of them had achieved growth that was above the standard for their dental age. No cases of cribra orbitalia or scurvy were reported among the infants. Only one case of porotic hyperostosis was identified in an infant individual, which was active at the time of death. The comparatively low rates of skeletal stress markers and better achieved growth indicates that the infants in HK43 sample were generally healthier than those from Akhetaten. This is further supported by the lack of evidence of poor maternal health.

HK43's achieved growth drops after 7.5 months, which is similar to the pattern seen the STC growth results. However, the average achieved growth for the toddler age group is significantly better when compared to the STC's values (Independent Samples t Test, p values < 0.01). The occurrence of cribra orbitalia is significantly lower in the HK43 toddlers (Fisher's exact test, p value = 0.0393), and no metabolic deficiencies were reported in this age group. This suggests that the HK43 toddlers were better at meeting their nutritional requirements during weaning than the STC samples, probably due to established sociocultural buffering systems and generally good maternal health for the population.

The HK43 sample appears to have poorer achieved growth for individuals in the early childhood age group. However, when compared to the STC the early childhood values are not significantly different for this age group. There is only a decline in achieved growth due to the high growth values seen in the younger age groups in the HK43 sample. As previously stated in the STC discussion, this would have been period of expansion in the child's environmental sphere, as well as an increase in independence and a complete reliance on solid food. The similar risk factors for these young children were likely comparable between the two samples in terms of chores and responsibilities. Egyptian women probably gave birth every two or three years, as lactation would have reduced their chance of pregnancy (Vymazalová and Strouhal 2014). Demands of pregnancy and new infant care on the mother could have reduced parental care for the older child placing them at greater risk in both populations. The complete independency from breast milk, as a source of nutrition, would have also exposed them to more food borne pathogens and illnesses.

The late childhood age group reported the most individuals with cribra orbitalia in the HK43 cemetery of which two cases were active at the times of death. HK43 was a workmen's cemetery, which meant these individuals could have been part of the local labor force. Late childhood subadults were expected to be contributors to their household, as well as becoming active members of their Egyptian community through apprenticeships to learn their new trade. The stratification of Egyptian society and the development of the elite class, would have required the need for more tradesmen, which could have then created the need for a greater agricultural labor force as the population grew (Batey 2012).

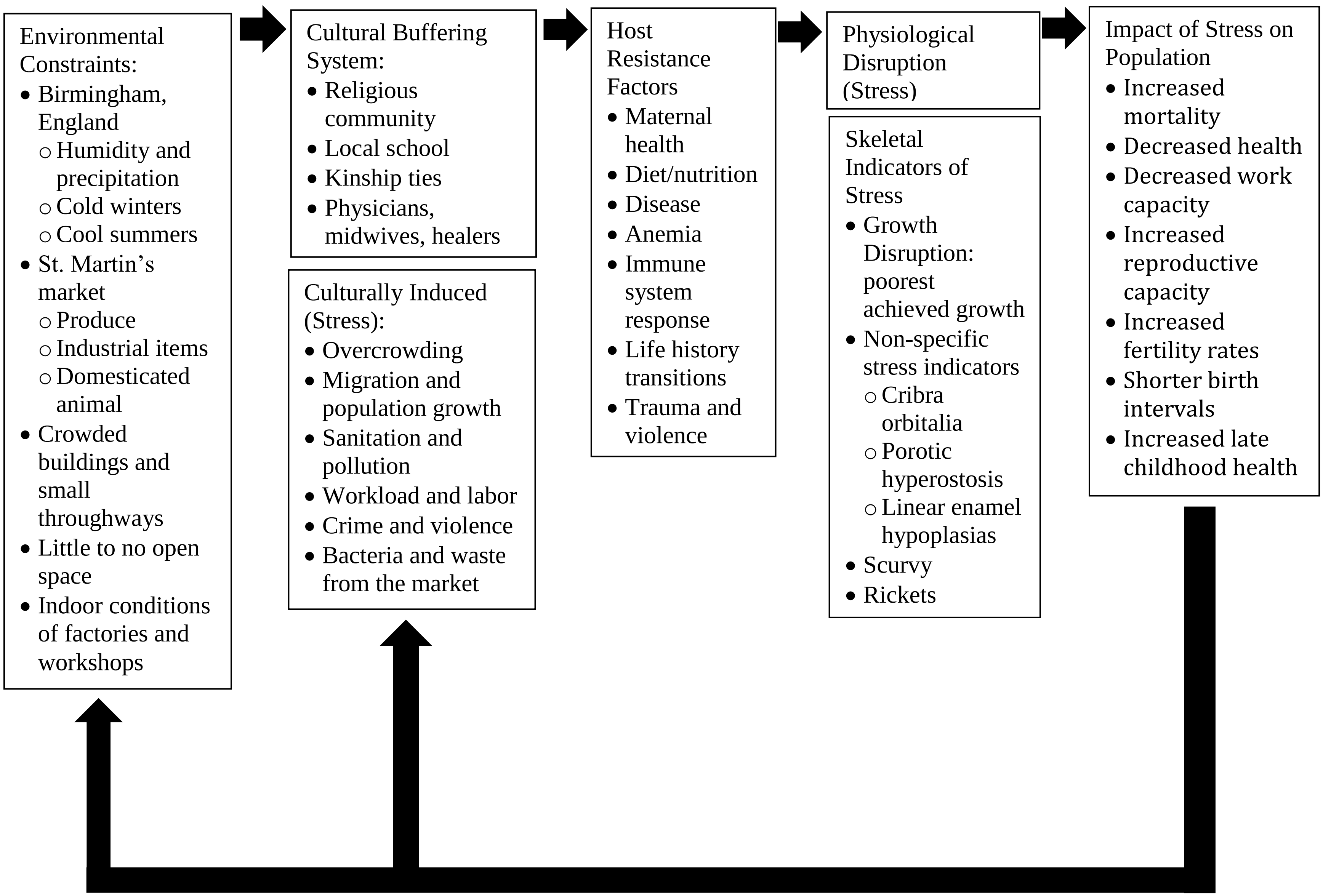
Achieved growth is better in the late childhood age group than the previous age stage. However, HK43 also has a decline in growth among the older late children and young adults similar to STC but not as severe. Adult stature increases during the Pre-dynastic period suggesting good health and childhood growth (Dabbs et al. 2015), which is consistent with the finding and interpretations of childhood in the HK43 cemetery.

St. Martin's Church Yard's Children and Childhood

Figure 19 is the biocultural model of childhood stress for the St. Martin's Church Yard in Birmingham, England, which is being used to represent childhood during the 18th century British Industrial Revolution. This was a period of great migration by rural populations moving to the urban industrials cities of Britain to meet the growing demand for manufacturing labor during this time. Birmingham's population more than doubled during the 18th century, which created housing deficiencies, overcrowding, high rates of violence, poor sanitation, and high industrial pollution. Inadequate or contaminated food supplies were a common concern in this urban environment. Even the SMC could not keep up with the growing demand of burial space for the expanding population in Birmingham at this time.

The SMC sample does not follow the expected normal demographic distribution. Although the SMC sample does have a higher percentage of infants than any other age group, when compared to the older age stages there is little difference in representation between these subadult categories. Similar to the Egyptian samples, infants from the SMC have the best achieved growth in the skeletal population when compared with the subadult sample. Low rates of cribra orbitalia and scurvy, along with no cases of porotic hyperostosis suggest that these infants were healthy in regard to these factors. However, the occurrence of LEHs on deciduous dentition and evidence of rickets suggest that this was still a period of high childhood stress, and that the population experienced poor maternal health. The effects of neonatal disruptions probably did not have time to manifest in the form of identifiable skeletal lesion prior to the death of the individual, which may explain the lack of certain skeletal stress markers.

Figure 19: Biocultural Model of Childhood Stress for the St. Martin's Churchyard



The SMC does show a drop in achieved growth and an increase in cribra orbitalia and rickets cases moving from infancy to toddlerhood. The lower achieved growth is not as severe as that seen in the STC, suggesting that the SMC had better growth among the individuals in the toddler age group. The number of individuals that were reported having rickets increases in frequency for the toddler age groups. Almost 50% of the toddlers had skeletal evidence of rickets, indicating a severe deficiency in vitamin D among these individuals. This is consistent with the high rates of rickets that have been historically documented among the children of Britain, so much so that it is referred to as the "English disease" (Mankin 1974). Mean age of weaning dropped in England during the 17th and 18th centuries, from 18 months to 7.25 months due to migration to the cities and the employment of women (Fildes 1986; Lewis 2007). This would have affected both the mother and child. Fertility rates would have increased and birth intervals would have shortened due to the decrease in the duration breastfeeding. Substitution and complementary feeding would have then been required to meet the nutritional demands of the growing child starting earlier. This would have resulted in a higher infant and toddler mortality, poor health, and growth disruptions. The use of replacement milks or formula would have put the child at risk of digesting contaminated food and increased the exposure to disease pathogens (Lewis 2007). Thus, the toddlers of the SMC were not receiving the adequate nutrients required for their growth and well-being.

The SMC early childhood achieved growth is poorer than what is reported for the toddler age group, which is different from the pattern observed in the STC sample. These early childhood individuals have the highest occurrence of cribra orbitalia but have lower rates of rickets for the SMC subadult sample. The lower rate of rickets cases may be due to increased exposure to sunlight with the child's increased ability to play and travel outdoors. However, the high rate of cribra orbitalia suggests that this was still a time of high childhood stress.

As was the case for the children of Akhetaten, the late subadults of SMC would have been expected or conscripted into the local labor forces during the late childhood age stage. Humphries states that "child labor was a major contributing factor in Britain's Industrialization" and has been an topic of interest among historians and archaeologists (2012: 6). Their duties and apprenticeships would include agricultural labor, mining, factory, skill trades, clerical, soldiering, and other various services. Hazardous conditions, long hours, physical labor, and poor sanitation would have impacted the health and mortality of these individuals. However, lower rates of cribra orbitalia, rickets, and better achieved growth among these older individuals suggest the economic gains, even as poor as they were, could have resulted in better access to nutrition and minerals that were originally lacking in their diets. Although the achieved growth rate of late childhood is better than what was reported in the early childhood age group, it was still the poorest compared to the other skeletal samples. The number of LEHs found on the permanent dentition of these individuals further indicates a high rate of childhood stress events. Generally, the childhood of the SMC children was one of poor health with high rates of skeletal stress and growth disruptions.

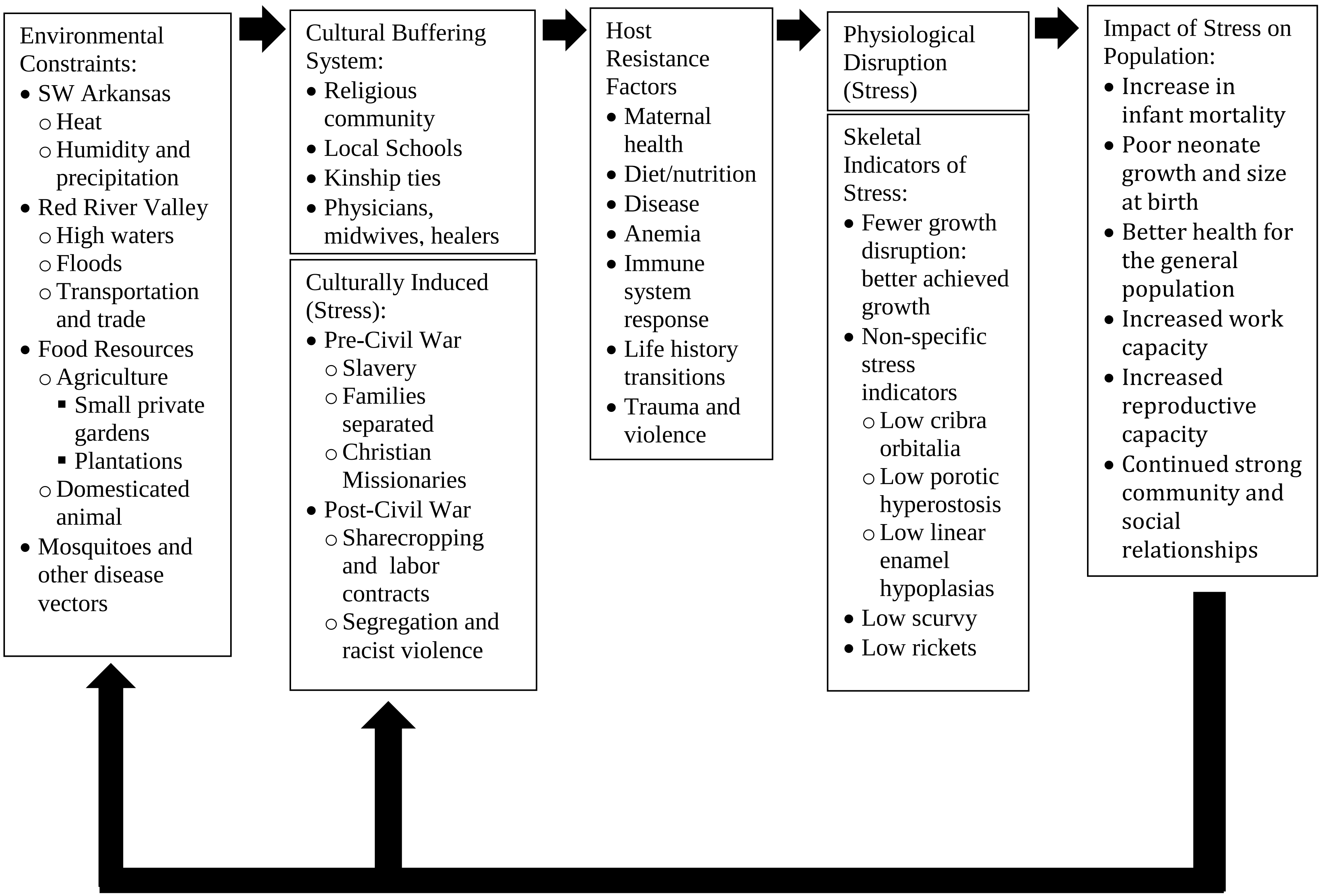
Cedar Grove Cemetery's Children and Childhood

Figure 20 is the biocultural model of childhood stress for the CGC, which is located in Lafayette County of Southwest Arkansas. The population is being used to represent rural African-American childhoods in the Southern United States after the end of the Civil War. The burials have been dated to 1900 to 1915 for this sample. The cemetery was associated with the

Cedar Grove Baptist Church, which remains an active sociocultural support system in this rural community today. The Church was established in 1881, and much of the local community life was centered around it and a local lodge. Watkins states that both of these would have provided the local African-American population with a "measure of independence and stability at a time when segregation had been legalized and racially motivated crime was high" (1985: 12). This community was a source for learning and social development. School was originally held in the Church, and a separate building was completed by 1948 (Foster 1980 cited from Watkins 1985). This community was small, but stable with an estimated population between 100 to 125 individuals (Watkins 1985). The local economy for the Cedar Grove population was dependent on local plant and animal agriculture for food.

The CGC sample follows a normal demographic distribution with high infant mortality and low representation of older subadults. The majority of the CGC subadults are infants, with most of them being approximately 1.5 months old at the time of death. Unlike the Egyptian samples, these neonates were small for their age based on their achieved growth status. This may be due to poor maternal health of the Cedar Grove mothers or other gestational and developmental concerns. Cribra orbitalia lesions were reported in three of infants from CGC, and all of the lesions were active at the time of death. One of these cribra orbitalia cases was an individual that was 1.5 months old that had porotic hyperostosis and evidence of possible scurvy, which supports a case for a gestational deficiency and poor maternal health.

Figure 20: Cedar Grove Cemetery's Biocultural Model of Childhood Stress.



The older age groups are less represented and have better achieved growth than the other skeletal populations. The majority of these individuals were meeting or exceeding the growth standard for their ages. This suggest that the general health of the CGC population greatly improved after the first six months of life and that the nutritional demands of these growing subadults appear to have been being met. This may have been the result of the strong sociocultural buffering systems that were in place within the Cedar Grove community. Although there is an increase in cases of cribra orbitalia among the CGC toddlers, rates of skeletal stress markers were low for the subadult sample. Low rates of LEHs in the older subadults indicate low rates of early childhood stress episodes even among these individuals. In terms of growth and childhoods, the subadult of CGC had a relatively good health status during childhood despite the uncertainty and marginalization of African-Americans during this time period.

Conclusion and Future Research

This dissertation examined the growth and health status of subadults from the STC population that grew up during the reign of Akhenaten by conducting a biocultural comparison using a Pre-dynastic Egyptian sample (HK43), a 18th century British Industrial sample (SMC), and a rural African-American sample (CGC). The STC subadult sample shows that these individuals were under extreme childhood stress as evidenced by the high rates of poor health indicators (cribra orbitalia, LEHs and scurvy) and reduced growth status. Periods or ages of transition were shown to have higher skeletal representation and poorer achieved growth among individuals in these categories. The degree and manner in which these stress episodes affected the health status and well-being of a subadult were highly dependent on the biocultural context of the individual sites. Migration, population growth, and manufacturing appear to have been major factors contributing to the poor health and growth of subadults in both the STC and SMC samples. However, the subadults' responses to these stress episodes were dependent on, and moderated by, the sociocultural buffering systems that were active within each population. The strong community ties of the CGC sample likely contributed to the better health status of its subadults, whereas the established settlement and agricultural innovations supplied the support needed for the HK43 subadults. The STC and SMC did not have strong sociocultural buffering systems to reduce the effects of childhood stress.

One of the goals of this dissertation was to contribute to the current biocultural research being conducted on children and childhood in the archaeological record by examining the growth and health of the subadult remains from the STC. A biocultural comparative framework has allowed us to contextualize our skeletal data which provides us with a clearer understanding of what it was like growing up during the reign of Akhenaten. The analyses conducted in this dissertation are a beginning step in examination of children and childhood at Akhetaten. Future endeavors are needed to increase our knowledge and understanding of what it means to be a child of the Aten.

References

Acosta, A., A. Goodman, J. Backstrand, and A. Dolphin 2003 Infants' Enamel Growth Disruptions and the Quantity and Quality of Mothers' Prenatal Diets in Solis, Mexico. American Journal of Physical Anthropology Suppl. 36:55.

Adams, J. 2006 The Parish, the Church, and the Churchyard. In St. Martin's Uncovered: Investigations in the Churchyard of St. Martin's-in-the-Bull Ring, Brinmingham, 2001, M. Brickley, S. Buteux, J. Adams, Cherrington, 6-23. Oxford: Oxbow Books.

Agarwal, S.C. and P. Beauchesne 2011 It is Not Carved in Bone: Development and Plasticity of the Aged Skeleton. In Social Bioarchaeology, Agarwal, S.C. and B.A. Glencross (eds), 312-332. Malden: Wiley-Blackwell

Agarwal, S.C. and B.A. Glencross 2011 Social Bioarchaeology. Malden: Wiley-Blackwell

Alfonso-Durruty, M.P. 2011 Experimental Assessment of Nutrition and Bone Growth's Velocity Effects on Harris Lines Formation. American Journal of Physical Anthropology 145: 169–180.

Allen, J.P. 2009 The Amarna Succession. In Causing his Name to Live: Studies in Egyptian History and Epigraphy in Memory of William J. Murnane, P.J. Brand and L. Cooper (eds.), 9-20. Leiden: Brill.

AlQahtani, S.J., M.P. Hector, and H.M. Liversidge. 2010 Brief Communication: The London Atlas of Human Tooth Development and Eruption. American Journal of Physical Anthropology. 142: 481-490.

Armelagos, G.J. 2003 Bioarchaeology as Anthropology. In Archaeology is Anthropology, S.D. Gillespie and D.L. Nichols (eds.), 27-41. Washington, DC: Archaeological Papers of the American Anthropological Association, No. 13.

Armelagos, G.J., J.H. Mielke, K.H. Owen, and D.P. van Gerven 1972 Bone Growth and Development in Prehistoric Populations from Sudanese Nubia. Journal of Human Evolution 1: 89–119.

Arneil, G. 1973 Rickets in Glasgow Today. The Practitioner 210:331-339.

Ascádi, G. and J. Nemeskéri 1970 History of Human Life Span and Mortality. Budapest: Akadémiai Kiadó.

Bagwell, E.A. 2002 Ceramic Form and Skill: attempting to identify child producers at Pecos Pueblo, New Mexico. In Children in the Prehistoric Puebloan Southwest, ed. Kathryn A. Kamp, 90-107. Salt Lake City, Utah: The University of Utah Press.

Baker, B., T. Dupras, and M. Tocheri. 2005 The Osteology of Infants and Children. College Station: Texas A&M University Press.

Baker, M. 1997 Invisibility of Gender Categories in Archaeology. In Invisible People and Process: Writing Gender and Childhood into European Archaeology, ed. Jenny Moore and Eleanor Scott, 183-191. London: Leicester University Press.

Barlow, T. 1883 On Cases Described as “Acute Rickets” Which are Probably a Combination of Scurvy and Rickets, the Scurvy Being Essential and the Rickets a Variable, Element. Medico-Chirurgical Transactions 66:159-219.

Batey, E.K. 2005 Subadult Skeletal Growth at Hierakonpolis, a Working Class Cemetery of Predynastic Egypt. American Journal of Physical Anthropology Suppl. 40:70.

Batey, E.K. 2012 Population dynamics in Predynastic Upper Egypt: Paleodemography of Cemetery HK43 at Hierakonpolis. Ph.D. Dissertation. University of Arkansas.

Baustian, K.M. 2010 Health Statud of Infants and Children from the Bronze Age Tomb at Tell Abraq, United Arab Emirates. MA Thesis, University of Nevada, Las Vegas, Las Vegas.

Baxter, J.E. 2005a Introduction: The Archaeology of Childhood in Context. Archeological Papers of the American Anthropological Association 15, no. 1: 1-9.

Baxter, J.E. 2005b Making Space for Children in Archaeological Interpretations. Archeological Papers of the American Anthropological Association 15, no. 1: 77-88.

Baxter, J.E. 2005c The Archaeology of Childhood: Children, Gender, and Material Culture. Walnut Creek, California: Altamira Press.

Binford, S.R. and L.R. Binford 1968 New Perspectives in Archaeology. Chicago: Aldine Transaction.

Blakely, M.L. and G.J. Armelagos 1985 Deciduous Enamel Defects in Prehistoric Americans from Dickson Mounds: Prenatal and Postnatal Stress. American Journal of Physical Anthropology 66:371-380.

Bogin, B. 1991 Measurement of Growth Variability and Environmental Quality in Guatemalan Children. Annals of Human Biology 18:285-294.

Bogin, B. 1997 Evolutionary Hypotheses for Human Childhood. Yearbook of Physical Anthropology 40:63-89.

Bogin, B. 1999 Pattern of Human Growth. 2nd edition. Cambridge, UK: Cambridge University Press.

Boldsen, J.L. 2007 Early Childhood Stress and Adult Age Mortality – A Study of Dental Enamel Hypoplasia in the Medieval Danish Village of Tirup. American Journal of Physical Anthropology 132:59-66.

Bouquet-Appel, J.P. and C. Masset. 1982 Farewell to Paleodemography. Journal of Human Evolution 11(4):321-333.

Bradley, C., and K.A. Kamp. 2002 Thoughts Count: Ideology and the Children of Sand Canyon Pueblo. In Children in the Prehistoric Puebloan Southwest, 169-195. Salt Lake City, Utah: The University of Utah Press.

Brickley, M. and R. Ives 2008 The Bioarchaeology of Metabolic Bone Diseases. Oxford: Academic Press, Elsevier Ltd.

Bugarin, F.T. 2005 Constructing an Archaeology of Children: Studying Children and Child Material Culture from the African Past. Archeological Papers of the American Anthropological Association 15(1): 13-26.

Buikstra, J.E. 1977 Biocultural Dimensions of Archaeological Study: A Regional Perspective. In Biocultural Adaptation in Prehistoric America, R.L. Blakely (ed.), 67-84. Athens: Southern Anthropological Society Proceedings, No 11, University of Georgia Press.

Buikstra, J.E. and C. Roberts, eds. 2012 The Global History of Paleopathology: Pioneers and Prospects. Oxford and New York: Oxford University Press.

Buikstra, J.E., and D.H. Ubelaker, eds. 1994 Standards: For Data Collection from the Human Skeletal Remains. Lafayette, Arkansas. Arkansas Archaeological survey Research Series No 44.

Buteux, S. 2006 Introduction. In St. Martin's Uncovered: Investigations in the Churchyard of St. Martin's-in-the-Bull Ring, Brinmingham, 2001, M. Brickley, S. Buteux, J. Adams, Cherrington, 1-5. Oxford: Oxbow Books.

Buteux, S. and R. Cherrington 2006 The Excavations. In St. Martin's Uncovered: Investigations in the Churchyard of St. Martin's-in-the-Bull Ring, Brinmingham, 2001, M. Brickley, S. Buteux, J. Adams, Cherrington, 24-89. Oxford: Oxbow Books.

Cameron, N.J. and B. Bogin 2012 Human Growth and Development. London: Elsevier Inc.

Cardoso, H.F.V. 2007 Environmental Effects on Skeletal Versus Dental Development: Using a Documented Subadult Skeletal Sample to Test a Basic Assumption in Human Osteological Research. American Journal of Physical Anthropology 132: 223-233.

Chamberlain, A.T. 1997 Commentary: Missing Stages of Life - towards the perception of children in archaeology. In Invisible People and Process: Writing Gender and Childhood into European Archaeology, ed. Jenny Moore and Eleanor Scott, 248-250. London: Leicester University Press.

Cheung, E., R. Mutahar, F. Assefa, M. Ververs, S.M. Nasiri, A. Borrel, and P. Salama 2003 An Epidemic of Scurvy in Afghanistan: Assessment and Response. Food and Nutrition Bulletin 24:247-255.

Chierici, R. and V. Vigi 1991 Dietary Trace Elements in Early Infancy. In Infantile Nutrition: An Update, R. Di Toro (ed.), 66-85. Naples: Karger.

Clayton, P. 1994 Chronicle of the Pharaohs: The Reign-by-Reign Record of the Rulers and Dynasties of Ancient Egypt. New York: Thames and Hudson.

Cook, D. and J.E. Buikstra 1979 Health and Differential Survival in Prehistoric Populations: Prenatal Dental Defects. American Journal of Physical Anthropology 51:649-664.

Crown, P.L. 2002 Learning and Teaching in the Prehispanic American Southwest. In Children in the Prehistoric Puebloan Southwest, ed. Kathryn A. Kamp, 108-124. Salt Lake City, Utah: The University of Utah Press.

Cunningham, C., L. Scheuer and S. Black 2016 Developmental Juvenile Osteology, 2nd ed. Oxford: Academic Press, Elsevier Ltd.

Dabbs, G.R., J.C. Rose, and M. Zabecki 2015 The Bioarchaeology of Akhetaten: Unexpected Results from a Capital City. In Egyptian Bioarchaeology: Human, Animals, and the Environment, S. Ikram, J. Kaiser, and R. Walker (eds), 43-52. Leiden: Sidestone Press.

Davidson, J.M., J.C. Rose, M.P. Gutmann, M.R. Haines, K. Condon, and C. Condon. 2002 The Quality of African-American Life in the Old Southwest near the Turn of the Twentieth Century. In The Back Bone of History. Ed. R.H. Steckel and J.C. Rose, 226-277. Cambridge, UK: Cambridge University Press.

Dettwyler, K.A. and C. Fishman 1992 Infant Feeding Practices and Growth. Annual Review of Anthropology 21:171-204.

Dickel, D.N. 1991 Descriptive Analysis of the Skeletal Collection from the Prehistoric Manasota Key Cemetery, Sarasota County, Florida (8SO1292). Florida Department of State, Bureau of Archaeological Research, Florida Archaeological Reports 22.

Dolphin, A. and A. Goodman 2002 The Influence of Maternal Diet on Pregnancy-forming Enamel Zinc Concentrations of Children from the Solis Valey, Mexico. American Journal of Physical Anthropology Suppl. 34:64.

Dougherty, S.P. and R.F. Friedman, R.F. 2008 Sacred or mundane: scalping and decapitation at Predynastic Hierakonpolis. In Egypt at its origins 2, B. Midant-Reynes and Y. Tristant (Eds.), 311–338. Leuvan: OLA.

El-Najjar, M.Y., B. Lozoff, and D. Ryan 1975 The Paleoepidemiology of Porotic Hyperostosis in the American Southwest: Radiological and Ecological Considerations. American Journal of Roentgenology, Radium Therapy, and Nuclear Medicine 125:918-924.

Emery, J., N. Varnham, and B. de Barr 2006 Foreward: The Birmingham Alliance. In St. Martin’s Uncovered: Investigations in the Churchyard of St. Martin’s-in-the-Bull Ring, Brinmingham, 2001, M. Brickley, S. Buteux, J. Adams, Cherrington, X. Oxford: Oxbow Books.

Eveleth, P.B. and J.M. Tanner 1976 Worldwide Variation in Human Growth. Cambridge: Cambridge University Press.

Fain, O. 2005 Musculoskeletal Manifestations of Scurvy. Joint Bone Spine 72:124-128.

Fenwick, H. 2005 Tell el-Amarna, 2005: Desert survey, Journal of Egyptian Archaeology 91:20–21.

Ferembach, D., I. Schwidetsky and M. Stloukal 1980 Recommendations for Age and Sex Diagnoses of Skeletons. Report of European Anthropologists (WEA). Journal of Human Evolution 9:517-549.

Fildes, V.A. 1986 Breasts, Bottles, and Babies. A History of Infant Feeding. Edinburgh: Edinburgh University Press.

Finlay, N. 1997 Kid Knapping: the missing children in lithic analysis. In Invisible People and Process: Writing Gender and Childhood into European Archaeology, ed. Jenny Moore and Eleanor Scott, 203-212. London: Leicester University Press.

Foote, K. and L. Marriott 2003 Weaning of Infants. Archives of Diseases in Childhood 88:488-492.

Forshee, B.A., M.F.Clayton, and K.L. McCance 2010 Stress and Disease. In Pathophysiology: The Biologic Basis for Disease in Adults and Children, 6th ed., McCance, K.L., S.E. Huether, and V.L. Bashers (eds.), 336-359. Maryland Heights: Mosby, Elsevier Ltd.

Foster, J. 1980 Informal Interview conducted December 2nd by B. Watkins of the Arkansas Archaeological Survey. Notes on File at the Arkansas Archaeological Survey and Cited in Watkins 1985.

Fraser, D.R. 1995 Vitamin D. Lancet 345:104-105.

Friedman, R.F., A. Maish, A.G. Fahmy, J.C. Darnell, and E.D. Johnson 1999. Preliminary report on field work at Hierakonpolis: 1996-1998. Journal of the American Research Center in Egypt 36:1–35.

Friedman, R.F., E. Watrall, J. Jones, A.G. Fahmy, W.V. Neer, and V. Linseele 2002 Excavations at Hierakonpolis. Arch´eo-Nil 12:55–68.

Gabolde, M. 1998 D’Akhenaton à Toutânkhamon, Lyon: Université Lumière-Lyon 2, Institut d’archéologie et d’historie de l’antiquité.

Gamza, T. and J. Irish 2010 A comparison of archaeological and dental evidence to determine diet at a predynastic Egyptian site. International Journal of Osteoarchaeology 22(4):398-408.

Goode, H., T. Waldron and J. Rogers 1993 Bone Growth in Juveniles: a Methodological Note. International Journal of Osteoarchaeology. 3(4): 321-323.

Goode-Null, S.K. 2002 Slavery's children: A study of growth and childhood sex ratios in the New York African Burial Ground. Ph.D. Dissertation. University of Massachusetts Amherst.

Goodman, A.H. 1993 On the Interpretation of health from skeletal remains. Current Anthropology 34:281-288.

Goodman, A.H. and G.J. Armelagos 1988 Childhood Stress and Decreased Longevity in a Prehistoric Population. American Anthropology 90:936-944.

Goodman, A.H. and J.C. Rose 1990 Assessment of Systemic Physiological Perturbations from Dental Enamel Hypoplasias and Associated Histological Structures. Yearbook of Physical Anthropology 33:59-110.

Gravlee, C.C. 2009 How Race Becomes Biology: Embodiment of Social Inequality. American Journal of Physical Anthropology 139(1):47-57.

Greene, T.R. 2006 Diet and dental health in Predynastic Egypt: a comparison of Hierakonpolis and Naqada. Ph.D. thesis. University of Alaska–Fairbanks.

Grewar, D. 1965 Infantile Scurvy. Clinical Pediatrics 4:82-89.

Griffith, J.P.C. 1919 The Diseases of Infants and Children. London: W.B. Saunders.

Halcrow, S.E., and N. Tayles. 2008. The Bioarchaeological Investigation of Childhood and Social Age: Problems and Prospects. Journal of Archaeological Method and Theory 15, no. 2 (June): 190-215.

Hammond, G. and N. Hammond 1981 Child’s Play: A Distorting Factor in Archaeological Distribution. American Antiquity 46:634-636.

Harlan, J.F. 1985 Predynastic settlement patterns: a view from Hierakonpolis. Ph.d. dissertation. Washington University. St. Louis.

Harris, J.R, 1973 Nefertiti Rediviva, Acta Orientalia 35:5-13.

Hassan, F.A. 1984 The beginnings of Egyptian civilization at Hierakonpolis. Quarterly Review of Archaeology 5:13–15.

Hawkes, K. 2006 Life History Theory Ans Human Evolution. In The Evolution of Human Life History, K. Hawkes and R. Paine (eds.). 45-94. School of American Research Advanced Seminar. Santa Fe, New Mexico: School of American Research Press.

Hays-Gilpin, K. 2002. Wearing a Butterfly, Coming of Age: A 1,500-Year-Old Pueblo Tradition. In Children in the Prehistoric Puebloan Southwest, ed. Kathryn A. Kamp, 196-210. Salt Lake City, Utah: The University of Utah Press.

Healey MJR. 1989. Growth curves and growth standards—the state of the art. In: Tanner JM, editor. Auxology 88. Perspectives in the science of growth and development. London: Smith-Gordon. p 13–21.

Hertz, D.G. 1993 Bio-Psycho-Social Consequences of Migration Stress: A Multidimensional Approach. Israel Journal of Psychiatry and Related Sciences 30(4):204-212.

Hill, K. and M. Hurtado 1996 Ache Life History: The Ecology and Demography of a Foraging People.New York, NY: Aldine De Gruyter.

Hillson, S., C. Grigson, and S. Bond 1998 Dental Defects of Congenital Syphilis. American Journal of Physical Anthropology 107:25-40.

Hoffman, M.A. (ed.) 1982 The Predynastic of Hierakonpolis: an interim report. Giza: Egyptian Studies Association.

Hoffman, M.A., H.A. Hamroush, and R.O. Allen, 1986 A model of urban development for the Hierakonpolis region from Predynastic through Old Kingdom times. Journal of the American Research Center in Egypt 23:175–187.

Hoppa, R. 2002 Paleodemography: looking back and thinking ahead. In Paleodemography:Age Distribution from Skeletal Samples, ed. Robert Hoppa, 9 – 28. Cambridge, UK: Cambridge University Press.

Hoppa, R. and K.L. Gruspier 1996 Estimating Diaphyseal Length from Fragmentary Subadult Skeletal Remains: Implications for Paleodemography Reconstruction of a Southern Ontario Ossuary. American Journal of Physical Anthropology 100:341-354.

Hornung, E. 1999 Akhenaten and the Religion of Light. Ithaca: Cornell University Press.

Hummert, J.R. and D.P. Van Gerven 1983 Skeletal Growth in a Medieval Population from Sudanese Nubia. American Journal of Physical Anthropology 62: 471-478.

Humphries, J. 2012 Childhood and Child Labour in the British Industrial Revolution. Economic History Review 66(2):1-24.

Irish, J.D. 2006 Who were the ancient Egyptians? Dental affinities among Neolithic through postdynastic peoples. American Journal of Physical Anthropology 129:529–543.

Jackes, M.K. 2000 Building the Bases for Paleodemographic Analysis: adult age determination. In Biological Anthropology of the Human Skeleton, M.A. Katzenberg and S.R. Saunders (eds.), 417-466. New York, NY: Wiley-Liss.

Jaffe, H.L. 1972 Metabolic degenerative and Inflammatory Diseases of Bones and Joints. Philadelphia: Lea and Febiger.

Janssen, R. and J.J. Janssen 2007 Growing up and Getting old in Ancient Egypt. Norfolk: Golden House Publication.

Jantz, R.L. and D.W. Owsley 1984 Long Bone Growth Variation Among Arikara Skeletal Populations. American Journal of Physical Anthropology 63:13-20.

Johnston, F.E. 1962 Growth of Long Bones of Infants and Young Children at Indian Knoll. American Journal of Physical Anthropology 20: 249–254.

Johnston, F.E., and L. Zimmerman 1989 Assessment of Growth and Age in the Immature Skeleton. In Reconstruction of Life from the Skeleton. M.Y. Iscan and KAR Kennedy, eds. Pp. 11–22. New York: Alan R. Liss.

Kaczmarek, M. 2003 Assessment of Growth Patterns in Juvenile Skeletons from Saqqara, PAM XIV (Reports 2002), 155–161.

Kaczmarek, M. 2012 Anthropological Studies on Juvenile Skeletal Remains from the Necroppolis at Marina el-Alamein, Egypt. Etudes Alexandrines 26: 293.313.

Kamp, K.A. 2001. Where Have All the Children Gone?: The Archaeology of Childhood. Journal of Archaeological Method & Theory 8, no. 1 (March): 1-34.

Kamp, K.A. 2002. Working for a Living: Childhood in the Prehistoric Southwestern Pueblos. In Children in the Prehistoric Puebloan Southwest, ed. Kathryn A. Kamp, 71-89. Salt Lake City, Utah: The University of Utah Press.

Kamp, K.A. 2005. Dominant Discourses; Lived Experiences: Studying the Archaeology of Children and Childhood. Archeological Papers of the American Anthropological Association 15, no. 1: 115-122.

Kamp, Kathryn A., and John C. Whittaker. 2002. Prehistoric Puebloan Children in Archaeology and Art. In Children in the Prehistoric Puebloan Southwest, ed. Kathryn A. Kamp, 14-40. Salt Lake City, Utah: The University of Utah Press.

Katzenberg, M.A. and S.R. Saunders 2008 Biological Anthropology of the Human Skeleton. Hoboken: John Wiley and Sons, Inc.

Keith, K. 2005. Childhood Learning and the Distribution of Knowledge in Foraging Societies. Archeological Papers of the American Anthropological Association 15, no. 1: 27-40.

Kemp, B.J. 1989. Ancient Egypt: Anatomy of a Civilization. Routledge: London.

Kemp, B.J. 2012. The City of Akhenaten and Nefertiti: Amarna and Its People. New Aspects of Antiquity. London: Thames & Hudson.

Kemp, B, A Stevens, GR Dabbs, M Zabecki3 and JC Rose 2013 Life, death and beyond in Akhenaten's Egypt: excavating the South Tombs Cemetery at Amarna. Antiquity. 87: 64–78.

King, T., L. Humphrey, and S. Hillson 2002 Developmental Stress in a Post-medieval Population of Londoners. American Journal of Physical Anthropology Suppl. 34:95.

Knick, S.G. 1982 Linear Enamel Hypoplasias and Tuberculosis in Pre-Columbian North America. Ossa 8:131-138.

Knussman, R. 1988 Anthropologie. Handbuch der vergleichenden biologie des menschen. Band 1. Stuttgart: Gustav Fisher.

Konner, M. 2005 Hunter-Gatherer Infancy and Childhood: The !Kung and Others. In Hunter-Gatherer Childhoods: Evolutionary, Developmental, and Cultural Perspectives, B.S. Hewlett and M.E. Lamb (eds.), 19-64. New Brunswick: Transaction Publishers.

Kreshover, S.J. 1960 Metabolic Disturbances in Tooth Formation. Annals of the New York Academy of Sciences 85:161-167.

Kronfield, R. and I. Schour 1939 Neonatal Dental Hypoplasias. Journal of the American Dental Association 26:18-32.

Kumar, A. 2009 Health at Hierakonpolis, a Predynastic settlement in Upper Egypt. Ph.d. dissertation. University of Arkansas, Fayetteville.

Kuo, A.A., M. Inkelas, W.M. Slusser, M. Maidenberg, and N. Halfon 2011 Introduction of Solid Food to Young Infants. Maternal Child Health Journal 15:1185-1194.

Kuznets, S.S. 1966 Modern Economic Growth: Rate, Structure and Spread. New Haven, Yale University Press.

Lampl, M. and F.E. Johnston 1996 Problems in the Aging of Skeletal Juveniles: Perspectives from Maturation Assessments of Living Children. American Journal of Physical Anthropology 101: 345–355.

Larsen, C.S. 1997 Bioarchaeology: Interpreting Behavior from the Human Skeleton. Cambridge: Cambridge University Press.

Lee, C.T. and S. Tuljapurkar 2008 Population and Prehistory I: Food-dependent Population Growth in Constant Environments. Theoretical Population Biology 73, 473–482.

Levine, R. and J. Keen 1974 Neonatal Enamel Hypoplasias in Association with Symptomatic Neonatal Hypocalcaemia. British Dental Journal 137:429-433.

Lewis, M.E. 2007 The Bioarchaeology of Children: Perspectives from Biological and Forensic Anthropology. Cambridge, UK: Cambridge University Press.

Lillehammer, G. 1989 Child is Born: The Child's World in Archaeological Perspective. Norwegian Archaeological Review 22 (2): 89-105.

Lillehammer, G. 2000. The World of Children. In Children and Material Culture, 17-26. New York, NY: Routledge.

Lillie, M.C. 1997. Women and Children in Prehistory: resource sharing and social stratification at the Mesolithic-Neolithic transition in Ukraine. In Invisible People and Process: Writing Gender and Childhood into European Archaeology, ed. Jenny Moore and Eleanor Scott, 213-228. London: Leicester University Press.

Mankin, H.J. 1974 Rickets, Osteomalacia, and Renal Osteodystrophy. Journal of Bone and Joint Surgery 56(A):101-128, 352-386.

Martin, D.L., R.P. Harrod, and V.R. Perez 2013 Bioarchaeology: An Intergrated Approach to Working with Human Remains. New York: Springer.

Martin, R. and K. Saller 1957 Lehrbuch der anthropolgie in systematisher darstellung. Vol. 1. Stuggart: Gustav Fisher.

Mays, S. 1995 The Relationship between Harris Lines and Other Aspects of Skeletal Development in Adults and Juveniles. Journal of Archaeological Science 22:511-520.

Mays, S., M. Brickley, and R. Ives 2006 Skeletal Manifestations of Rickets in Infants and Young Children in a Historic Population from England. American Journal of Physical Anthropology 129:362-374.

Mays, S., M. Brickley, and R. Ives 2008 Growth in an English Population from the Industrial Revolution. American Journal of Physical Anthropology 136: 85-92.

Mays, S., R. Ives, and M. Brickley 2009 The Effects of Socioeconomic Status on Endochrondral and Appositional Bone Growth, and Acquisition of Cortical Bone in Children from 19th Century Birmingham, England. American Journal of Physical Anthropology 140: 410-416.

Meskell, L. 2002 Private Life in New Kingdom Egypt. Princeton and Oxford: Princeton University Press.

Miles, A.E.W. and J.S. Bulman 1994 Growth Curves of Immature Bones from a Scottish Island Population of Sixteenth to Mid-Nineteenth Century: Limb-bone Diaphysis and Some Bones of the Hand and Foot. International Journal of Osteoarchaeology 4:121-136.

Möller, V. 1862 Zwei von Acuter Rachitis. Königsberger Medizinische Jahrbücher 3:136-149.

Moore, J. 1997. Conclusion: the visibility of the visible. In Invisible People and Process: Writing Gender and Childhood into European Archaeology, ed. Jenny Moore and Eleanor Scott, 251-257. London: Leicester University Press.

Murnane, W. 1995 Texts from the Amarna Period in Egypt. In SBL Writings from the Ancient World Series. Ed. by Edmund S. Meltzer. Atlanta: Scholars Press

Noren, J., B. Magnusson, and H. Grahnen 1978 Mineralization Defects in Primary Teeth in Intr-Uterine Undernutrition. II. A Histological and Microradiographic Study. Swedish Dental Journal 2:67-72.

Oris, M., R. Derosas, and M. Breschi 2004 Infant and Child Mortality. In Life Under Pressure. Mortality and Living Standards in Europe and Asia, 1700-1900. T. Bengtsson, C. Campbell, and J. Lee (eds.), 359-398. Cambridge, MA: MIT Press.

Ortner, D. 2003 Identification of Pathological Conditions in Human Skeletal Remains. 2nd ed. San Diego: Academic Press.

Paine, R.R. and J.L. Boldsen 2002. Linking age-at-death distri- butions and ancient population dynamics: a case study. In Paleodemography: Age Distributions from Skeletal Samples, R. Hoppa and J.W. Vaupel (eds), 169-180. Cambridge: Cambridge University Press.

Pimentel, L. 2003 Scurvy: Historical Review and Current Diagnostic Approach. American Journal of Emergency Medicine 21:328-332.

Paine, R. and K. Hawkes 2006 Introduction. In The Evolution of Human Life History, K. Hawkes and R. Paines (eds.). 3-16. School of American Research Advanced Seminar. Santa Fe, New Mexico: School of American Research Press.

Panter-Brick, C. 1998 Biosocial Perspective of Children. Cambridge, UK: Cambridge University Press.

Pitt, M.J. 1988 Rickets and Osteomalacia. In Diagnosis of Bone and Joint Disorders, D. Resnick and G. Niwayama (eds.), 2087-2126. Philadelphia: W.B. Saunders.

Redford, D.B. 2013 Akhetaten: New Theories and Old Facts*. American Schools for Oriental Research. BASOR 369:9-34.

Reeves, N. 2001 Akhenaten: Egypt's False Prophet. London: Thames and Hudson.

Reid, D. J., and M. C. Dean. 2000. "Brief communication: the timing of linear hypoplasias on human anterior teeth." American Journal of Physical Anthropology 113(1):135–39.

Roberts, C. and K. Manchester 2007 The Archaeology of Disease. 3rd ed. Ithaca: Cornell University Press.

Robertson, A.F. 1996 The Development of Meaning: Ontogeny and Culture. Journal of The Royal Anthropological Institute 2(4):591-610.

Roksandic, M. and S. Armstrong 2011 Using the Life History Model to Set the Stage(s) of Growth and Senescence in Bioarchaeology and Paleodemography. American Journal of Physical Anthropology 145: 337-347.

Rose, J.C. 1985 Gone to a Better Land. Arkansas Archaaeological Survey Research Series No. 25

Rose, J.C., G.J. Armelagos, and J.W. Lallo 1978 Histological Enamel Indicator of Childhood Stress in Prehistoric Skeletal Samples. American Journal of Physical Anthropology 49:511-519.

Rose, J.C., K.W. Condon, and A.H. Goodman 1985 Diet and Dentition: Developmental Disturbances. In The Analysis of Prehistoric Diets, R.I. Gilbert and J.M. Meilke (eds.), 281-305. Orlando: Academic Press.

Rose, J.C. and G.R. Dabbs 2014 Report on the 2014 Skeletal Analysis of the South Tombs Cemetery Project

Sarnat, B.G. and I. Schour 1941 Enamel Hypoplasia (Chronological Enamel Aplasia) in Relation to Systemic Disease: a Chronologic, Morphologic, and Etiologic Classification. Journal of the American Dental Association 28:1989-2000.

Saunders, S., R.D. Hoppa, and R. Southern 1993 Diaphyseal Growth in a Nineteenth Century Skeletal Sample of Subadults from St. Thomas's Church, Belleville Ontario. Internation Journal of Osteoarchaeology 3: 265–281.

Sciulli, P.W. 1994 Standardization of Long Bone Growth in Children. International Journal of Osteoarchaeology. 4: 257-259.

Scheuer, L. and S. Black 2000 Developmental Juvenile Osteology, 1st ed. Oxford: Academic Press, Elsevier Ltd.

Scheuer, L. and S. Black 2004 The Juvenile Skeleton. London, UK: Academic Press, Elsevier Ltd.

Schneider, T. 1994 Lexikon der Pharaonen, Zurich: Artemis Verlag.

Schwartzman, H.B. 2005 Materializing Children: Challenges for the Archaeology of Childhood. Archeological Papers of the American Anthropological Association 15(1): 123-131.

Scott, E. 1999 The Archaeology of Infancy and Infant Death. BAR (International Series) no. 819. Oxford: Archaeopress.

Sellen, D.W. 2006 Lactation, Complementary Feeding, and Human Life History. In The Evolution of Human Life History, K. Hawkes and R. Paine (eds.). 3-16. School of American Research Advanced Seminar. Santa Fe, New Mexico: School of American Research Press.

Seow, K.W. 1992 Dental Enamel Defects in Low Birthweight Children. Journa of Paleopathology Monographic Publication 2:321-330.

Shaw, I. 2000 The Oxford history of Ancient Egypt. New York: Oxford University Press.

Sofaer Derevenski, J. 1997 Engendering Children, Engendering Archaeology. In Invisible People and Process: Writing Gender and Childhood into European Archaeology, ed. Jenny Moore and Eleanor Scott, 192-202. London: Leicester University Press.

Stearns, S.C.1992 The Evolution of Life Histories. Oxford: Oxford University Press.

Stearns, S.C. and J. Koella 1986 The Evolution of Phenotypic Plasticity in Life-history traits: predictions of norms of reaction for age and size at maturity. Evolution 40:893-913.

Stevens, A. 2017 Death and the City: The Cemeteries of Amarna in their Urban Context. Cambridge Archaeological Journal: 1-24.

Stevens, A. and M. Eccleston 2007 Craft Production and Technology. In The Egyptian World, T. Wilkerston (ed.), 146-159. London and New York: Routledge.

Stone, I. 1965 Studies of a Mammalian Enzyme System for Producing Evolutionary Evidence in Man. American Journal of Physical Anthropology 23:83-85.

Strouhal, E., B. Vachala, and H. Vymazalová 2014 The Medicine of the Ancient Egyptians. Cairo and New York: The American University in Cairo Press.

Stuart-MacAdam, P.L. 1989 Nutritional Deficiency Diseases: A Survey of Scurvy, Rickets, and Iron Deficiency Anemia. In Reconstruction of Life from the Skeleton, M.Y. Isçan and K.A.R. Kennedy (eds.), 201-222. New York: Wiley-Liss.

Stuart-MacAdam, P.L. 1991 Anemia in Roman Britain: Poundbury Camp. In Health in Past Societies: Biocultural Interpretations of Human Skeletal Remains in Archaeological Contexts, BAR (International Series), no S567, H. Bush and M. Zvelebil (eds.), 101-113. Oxford: Archaeopress.

Sweeney, E.A., A.J. Saffir, and R. De Leon 1971 Linear Hypoplasias of Deciduous Incisors Teeth in Malnourished Children. American Journal of Clinical Nutrition 24:29-31.

Szabo, S., Y. Tache and A. Somogyi 2012 The Legacy of Hans Selye and the Origins of Stress Research: A retrospective 75 years after his landmark brief “Letter” to the Editor of Nature. Stress 15(5):472-478.

Tanner, J. M. 1981 A history of the study of human growth. New York: Cambridge University Press.

Tanner, J.M. 1990 Foetus into Man: Physical Growth from Conception to Maturity. Cambridge, MA: Harvard University Press.

Taylor, O.W. 1958 Negro Slavery in Arkansas. Duke University, Durham.

Taylor, O.W. 1959 A Letter from the Governor James S. Conway to His Plantation Overseer. Arkansas Historical Quarterly 18:90-92.

Thomas, K. 2005 The “Nature” of Childhood: Ethnography as a Tool in Approaching Children in Archaeology. Archeological Papers of the American Anthropological Association 15(1): 41-50.

United Nations. 1955. Age and Sex Patterns of Mortality: Model Life-Tables for Under-Developed Countries. New York: Department of Social Affairs Population Branch.

Van de Mieroop, M. 2011 A History of Ancient Egypt. Malden: Wiley-Blackwell

Vandersleyen, C. 1995 L’Égypte et la vallée du Nil, Tome 2. De la fin de l’Ancien Empire á la fin du Nouvel Empire, Paris: Presses Universitaires de France.

Vymazalová, H. and E. Strouhal 2014 Mother and Childcare. In The Medicine of the Ancient Egyptians, Strouhal, E., B. Vachala, and H. Vymazalová (eds), 97-204. Cairo and New York: The American University in Cairo Press.

Walker, P.L. 1985 Anemia among Prehistoric Indians of the American Southwest. In Health and Disease in the Prehistoric Southwest, C.F. Merbs and R.J. Miller (eds.), 139-164. Arizona State University Anthropological Research Papers 34.

Walker, P.L. 1986 Porotic Hyperostosis in a Marine-Dependent California Indian Population. American Journal of Physical Anthropology 69:345-354.

Walker, P.L. 2001 A Bioarchaeological Perspective on the History of Violence. Annual Review of Anthropology 30:573-596.

Walker, R., M. Gurven, K. Hill, A. Migliano, N. Chagnon, R. De Souza, G. Djurovic, R. Hames, A.M. Hurtado, H. Kaplan, K. Kramer, W. Oliver, C. Valeggia and T. Yamaughi 2006 Growth Rates and Life Histories in Twenty-Two Small-Scale Societies. American Journal of Human Biology 18: 295-311.

Wapler, U., E. Crubézy, and M. Shultz 2004 Is Cribra Orbitalia Synonymous with Anemia? Analysis and Interpretation of Cranial Pathology in Sudan. American Journal of Physical Anthropology 123:333-339.

Watkins, B. 1985 Historical Background. In Gone to a Better Land, J.C. Rose (ed.), 6-25. Arkansas Archaaeological Survey Research Series No. 25

Wengrow, D. 2006 The archaeology of early Egypt: social transformations in North-East Africa, 10,000 to 2,650 BC. Cambridge: Cambridge University Press.

Wheeler, S.M. 2009 Bioarchaeology of Infancy and Childhood at the Kellis 2 Cemetery, Dakhleh Oasis, Egypt. Ph.d. dissertation. University of Western Ontario, London.

White, T., M.T. Black, and P.A. Folkens. Human Osteology, 3rd ed. Oxford: Academic Press.

Wilkinson, T.A.H. 1999 Early dynastic Egypt. London: Routledge.

Wood, J. W., G. R. Milner, H. C. Harpending, and K. M. Weiss 1992 The osteological paradox: Problems of inferring health from skeletal samples. Current Anthropology 33(4):343-370.

Xi, J. 2014 Migration, Stress, and Health. In The Wiley-Blackwell Encyclopedia of Health, Illness, Behavior, and Society, Vol. IV, W.C. Cockerham, R. Dingwall, and S. Quah (eds.), 1654-1656. Malden: Wiley-Blackwell.

Y'Edynak, G. 1976 Long Bone Growth in Western Eskimo and Aleut Skeletons. American Journal of Physical Anthropology 45: 569–574.

Zabecki, M. 2009 Late Predynastic Egyptian workloads: musculoskeletal stress markers at Hierakonpolis. Ph.d. dissertation. University of Arkansas. Fayetteville.

Zakrzewski, S.R. 2007 Population continuity or population change: formation of the ancient Egyptian state. American Journal of Physical Anthropology 132: 501–509.

Zuckerman, M.K. and G.J. Armelagos 2011 The Origins of Biocultural Dimensions in Bioarchaeology. In Social Bioarchaeology, S.C. Agarwal and B.A. Glencross (eds.), 15-43. Malden: Wiley-Blackwell.